DOCUMENT RESUME

ED 033 036 SE 007 474

Diggers to Divers. Geology K-6; Elementary Science Unit No. 2.
Bethlehem Area Schools, Pa.
Pub Date 68
Note-217p.
EDRS Price MF-$1.00 HC Not Available from EDRS.
Descriptors-Concept Formation, *Curriculum Guides, Discovery Learning, *Earth Science, *Elementary School Science, *Geology, Instructional Materials, Marine Biology, Oceanology, Problem Solving, *Science Activities, Teaching Procedures

This curriculum guide, part of a series of science units, stresses concept-learning through the discovery approach and child-centered activities. It is intended that the unit will be studied in depth by grades 3, 4, 5, and 6. Kindergarten pupils will study the unit in less detail. "Our Useful Rocks" is studied in the kindergarten, "Rocks - Then and Now" in grade 3, "Petrology" in grade 4, "Oceanography" in grade 5, and "Geology" in grade 6. The section for each grade contains (1) understandings to be discovered, (2) activities, and (3) activities to assign for homework or individual research. Each activity is introduced by a "leading question," followed by a list of materials and a description of the procedure to be followed. Children are taught to observe, infer, discuss problems and use reference and audio-visual aid materials. There is an index of science textbooks for reference for the teacher. The 40-page appendix contains (1) a brief geological history of Northampton County, Pennsylvania, (2) a description of a geological field trip to Northampton County, (3) a description of the common rocks and minerals, and (4) various geological and oceanographic charts, maps and tables. [Not available in hard copy due to marginal legibility of original document]. (LC)

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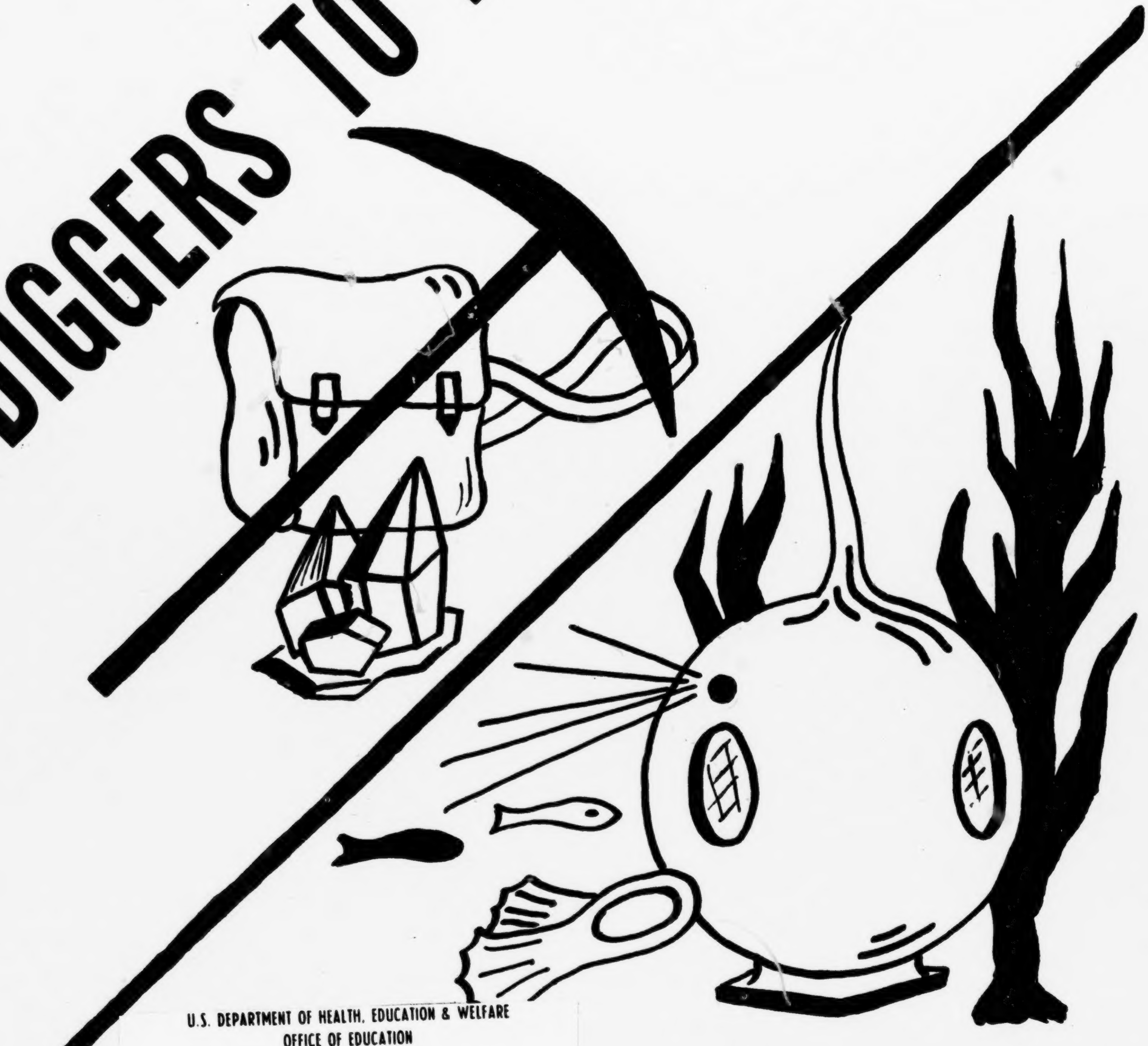
DIGGERS TO DIVERS

(Geology)

K–6



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Elementary Science Unit No. 2
1968

Bethlehem Area School District
Bethlehem, Pennsylvania

DIGGERS TO DIVERS

(Geology)

K-6

BETHLEHEM AREA ELEMENTARY SCHOOLS

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1968

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FOREWORD

The Diggers to Divers Unit (Geology) is the second of a series of units to be written for the Bethlehem Area Elementary Schools. It is a major revision in both structure and content of the Earth Science Unit in the second edition of the Science Curriculum Guide.

In the first two editions of the Science Curriculum Guide, all areas of science were part of the curriculum at succeeding grade levels with ever increasing detail. This third edition will provide for differentiation of emphasis. Certain units will receive major emphasis at prescribed grade levels and minor emphasis at other grade levels. Designated grade levels will not study particular units at all except as current events. The result will be that each grade level will study fewer areas but in greater detail.

The Diggers to Divers Unit should be studied in depth in the third, fourth, fifth, and sixth grades. Kindergarten will study geology in less detail or with minor emphasis. Grades one and two will not have a unit in geology.

Grades three, four, five, and six should spend approximately four to six weeks with material at their prescribed level. Kindergarten will spend approximately two weeks discussing material at their level.

The Diggers to Divers Unit should also be used as a resource unit for correlating the city trip of the third grade social studies program and the Northampton County fourth grade field trip.

The unit for each grade in this book will usually contain:

1. UNDERSTANDINGS TO BE DISCOVERED with a cross-reference

2. ACTIVITIES

3. ACTIVITIES TO ASSIGN FOR HOMEWORK OR INDIVIDUAL RESEARCH

The UNDERSTANDINGS TO BE DISCOVERED are listed for teacher reference and to be developed through child-centered activities. A teacher should choose activities that best suit the need of the students. Obviously it would be impractical to use every activity listed.

Do not begin a lesson by stating a concept and proceeding to "prove" it with one or more experiments. Allow children to discover a concept in a learning situation. Children themselves should find solutions when confronted with a problem.

Teach children to observe, draw conclusions from observations, discuss problems with fellow students and other people, and to use a variety of references and audio-visual aid materials. Classroom textbooks should be used as reference materials in addition to the encyclopedias and books found in the library.

The science textbooks have been indexed for quick reference for the teacher in the Diggers to Divers Unit. This index is not to be used by students. Children should practice basic reading skills by using the table of contents and the index in their textbooks to discover pertinent references.

ACKNOWLEDGMENTS

The Science Curriculum Revision Committee acknowledges the debt of gratitude it owes to Dr. Keith E. Chave and Dr. J. Donald Ryan of the Department of Geology, Lehigh University, for their assistance in reading the manuscript, "Diggers to Divers", for scientific accuracy. Their suggestions and guidance have been an invaluable aid in the completion of this project.

The cooperative effort of the Lehigh University staff and the curriculum writing team has resulted in a program through which the elementary teaching staff of the Bethlehem Area Schools can improve the learning opportunities for boys and girls in our community.

DIGGERS TO DIVERS

Our Useful Rocks Kindergarten

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
A rock is a piece of matter that is non-living.	1
Rocks have different sizes.	2
Some rocks contain fossils of plants and animals.	3,4
Rocks have many uses.	5
Rocks have many shapes.	6
Rocks differ in color.	7
Rocks have many different textures.	8
Some rocks are harder than others.	9,10
Some rocks break easily.	10,11,12,13
Rocks are broken in many ways.	11,12,13,14
Rocks are sharp when they are broken.	12,13,14
Some rocks are heavier than others.	15
Wind and water change the size, shape, and place of rocks.	13,16,17
Small particles of rock help to make soil.	18,19
Soil covers most of the earth's surface.	20
Plants, animals, and man make use of soil in various ways.	21,22,23,24
Water covers most of the earth's soil and rock..	25

DIGGERS TO DIVERS

Our Useful Rocks

Kindergarten

ACTIVITIES

1. Leading Question: Are rocks alive?

Materials: Rocks of many sizes, shapes, hardness, and colors

Procedure: Children manipulate and examine rocks. Encourage them to make observations concerning the rocks. Record children's thoughts and conclusions such as: Rocks cannot walk around by themselves. Rocks do not have to be fed as they cannot eat. Rocks can't play games. Rocks do not sleep. Rocks do not grow like children do.

2. Leading Question: Are all rocks the same size?

Materials: Containers of sand, pebbles, stones, larger rocks of varying sizes, oaktag, magazines, paste, scissors, chart-size paper

Procedure: Encourage children to examine and handle rock materials which are piled on pieces of oaktag on a table. Discuss the common names of various rock materials. Through questioning, ascertain if children realize that all are rocks. Develop the understanding that rocks are of many and varied sizes ranging from a grain of sand to a boulder as large as and some times larger than a house. Classify the rocks in piles according to size from the smallest to the largest. Collect, cut out, and paste pictures to make a chart showing the range of differences in the size of rocks.

3. Leading Question: Can we find pictures in rocks?

Materials: Fossil kits from Science Room, reading glass, giant tripod magnifier

Procedure: Allow children through handling of the rocks, to discover traces of plants or animals. Encourage the children to look at the rocks with the giant tripod magnifier or the reading glass. Through discussion, encourage the children to give their theories of how the pictures got there. Are we able to see the whole plant or animal? Were the plants or animals small or large? Are the children able to make inferences as to where the plants or animals lived originally - in the water or on the land? Do we have any plants or animals like the ones we can see in the rocks?

Note to teacher: The children may be interested in knowing that the word FOSSIL is from a Latin word which means "dug up."

4. Leading Question: How were fossil prints made?

Materials: Plaster of Paris, water, aluminum pans of varying sizes, clam shells or other sea shells

Procedure: Have each child prepare his own mixture of two parts of plaster of Paris to one part water. The consistency should be like pancake batter. Pour the plaster into the aluminum pans. Put the shells into the plaster of Paris mixture. Remove the shells the next day. The shell prints will look much like a fossil print.

5. Leading Question: How do we use rocks?

Materials: Magazines, scissors, construction paper, chart-size paper

Procedure: Pose the question, "Can you think of any ways you have seen rocks used?" The children will want to describe the many different ways they have noticed. List the children's examples. Some of these are: homes, schools, rock gardens, foundations of homes, patios, walks, walls, and for decorative purposes. Collect, cut out, and paste pictures from magazines on construction paper. Make a booklet to show the many ways in which rocks are used by people. Charts can also be made in the same manner.

6. Leading Question: Does wind affect the size or shape of rocks?

Materials: Pictures of rocks on the desert, opaque projector

Procedure: Have children look at the pictures carefully and tell you what they see. Ask them where they think the pictures were taken. Can the children make any inferences concerning the various shaped large rocks and the sand around them? Are the rocks all the same size? Are the rocks all the same shape?

7. Leading Question: Are all rocks the same color or are they different colors?

Materials: Rocks of many colors, pictures of different colored rocks, opaque projector

Procedure: Ask the children to collect and bring to school two or three small rocks. After placing all the rocks on a table, discuss their various colors. Classify the rocks by putting them into piles according to their color, such as: black, black and white, brown, red, white, etc. Using the opaque projector, view the available rock pictures. Discuss the coloring of the rocks.

8. Leading Question: Do all rocks feel the same?

Materials: Rocks of differing textures such as: sandstone, limestone, conglomerate, shale, slate, marble, granite, talc. (These rocks can all be found in the "Washington School Collection" in the Science Room.)

Procedure: Arrange rocks on tables. Tell the children to rub their fingers across each rock. Encourage close examination and much handling of all the rocks. Pose questions such as: Do all rocks feel the same when you handle them? Which rocks feel the same? Which feel differently? Do any rocks feel slippery or greasy? Which is the smoothest rock? Which rock feels roughest? Do small particles come off the rock when you rub it with your fingers? Are these pieces rough or smooth? Can you think of anything these small particles feel like?

9. Leading Question: Are some rocks harder than others?

Materials: Six or more rocks, pennies, nail files, four pieces of different colored chalk

Procedure: Arrange about six rocks on a table. Have children predict which rocks can be scratched with other rocks, fingernails, pennies, and nail files. Ask four children to volunteer to participate in the experiment. The other children will observe and comment as the four children develop the experiment. The first child using one rock tries to scratch all the other rocks. Another child tries to scratch each rock with his fingernail. The third child will try to scratch the rocks with a penny. The fourth child will use a nail file to try to scratch the rocks. Each of the four children should have a piece of different colored chalk. If he is able to scratch a rock using his instrument, he makes a mark on the table at that particular rock. After the experiment is completed, count the number of colored chalk marks to find out how many rocks could be scratched using each instrument. Are children able to determine which rocks are hardest and which rocks are softest?

10. Leading Question: Do all rocks need the same force to break them?

Materials: Different types of rocks, hammer

Procedure: Have children examine the rocks and predict which rocks will be easiest to break. Take three rocks and cover them with a cloth. Ask a child to tap each rock lightly with the hammer. Uncover and see if any of the rocks broke. Cover again and tap each rock a bit harder. Again check to see if any of the rocks broke. Continue in this manner hitting the rocks in the same order until they break. Which of the three rocks broke with the least amount of effort? Which rock had to be hit hardest to break? Classify rocks according to the amount of effort needed to break them. Check the predictions against the results.

11. Leading Question: Does ice have any effect on rocks?

Materials: Sandstone, shale, limestone, water, aluminum pan

Procedure: Put a piece of sandstone, shale, or limestone in a pail of water and allow it to become saturated. Remove from water and place it in an aluminum pan. If a refrigerator is available, place the pan in the freezer. If no refrigerator is available, this experiment can be performed on a very cold day. Encourage the children to make predictions as to what will happen to the rock. Before the children go home, have the rock checked. Are there any observable changes? Put the rock in the pan outdoors or in the refrigerator overnight and look at it the next day. Check for changes. Do this for a number of days, possibly a week. Review what happened to the rock when it was put into the water and then frozen. Relate this to the larger picture of rocks being broken by ice.

12. Leading Question: What causes rocks to break?

Materials: A supply of fist-sized rocks

Procedure: Ask the children what they think will happen if one rock is hit with another rock. Encourage them to speculate. Put one rock on the table. Ask a child to hit this rock with another rock after both rocks have been covered with a piece of cloth. What happened to the rocks? Have him hit the rock on the table again. Has anything different happened? Have him hit the rock again and again. Does the same thing happen each time the rocks are hit together? Relate this to the way rocks are broken by forces such as dynamite or a heavy rock falling on another rock.

Note to teacher: Bits of rock can be dangerous. Cover the rock with a piece of cloth before breaking.

13. Leading Question: What happens to rocks when they are in or near water?

Materials: Fragments of brick, small sharp rocks, a plastic or glass container with a top, water, magnifying glass

Procedure:

Place a piece of brick in a container of clear water. Add a few sharp, pea-sized rocks. Put on the top and shake the container slowly. After shaking the container about five times, allow the water to settle and see if any change has taken place. Ask children to take turns at shaking the container rapidly for a few minutes. Pour the contents of the container into a basin. Take out the pieces of rocks and the piece of brick. Do the pieces of rock look the same? Does the piece of brick look the same? Examine the contents of the basin. What is left in the basin besides the water? Encourage the children to use the magnifying glass. Are the children able to reason that the rubbing of the rocks against the brick caused the wearing away of the brick? Ask the children what they think would happen if they continued to shake the container with the rocks and piece of brick in it.

14. Leading Question: Do all rocks break in the same way?

Materials: Different kinds of rocks, hammer

Procedure:

Arrange the rocks on a table. Ask the children to anticipate what a rock will look like when it is broken. Through discussion and questioning, find out whether they think the edges of the rock will be smooth or irregular and jagged. Cover each rock to be broken with a piece of cloth. Allow each of a number of children to break one rock under your supervision. Did each rock break in approximately the same way? Were any of the edges smooth? Are the children able to come to any conclusions concerning the breakage of rocks?

15. Leading Question: Do rocks of equal size have the same weight?

Materials: A number of rocks of approximately the same size, a trip-balance scale

Procedure:

Place the rocks on a table and ask the children to gather around it. Encourage the children to hold a rock in each hand and decide if the rocks are of equal weight or if one is heavier than the other. Weigh the rocks on a trip-balance scale. Are the rocks the same weight? Which rock is heavier? Which rock is lighter? Record the weight for the two rocks. Do this for each child who is holding the two rocks. Can we find two rocks of equal weight? What conclusion can the children make from this experience?

16. Leading Question: Are rocks the same all over the world?

Materials: Rocks from different areas such as: lake, creek, river, ocean, mountain, field, and roadside

Procedure: Place the rocks on a table and cover them with a cloth. Have the children describe the appearance of the rocks which they have seen in different localities. Were the rocks they saw on land or in the water? Remove the cloth from the rocks on the table. Ask different children to describe the rocks which are on the table. Where do they think the rocks were found? Question them to find the reasons for their choices. Classify them according to their placement. The rounded rocks are usually found in or about water; the jagged, rough ones are found on the land.

17. **Leading Question:** How does water move rocks and which rocks move farthest?

Materials: Sand, soil, pebbles, larger rocks, board, container to catch water, sprinkling can and water

Procedure: Put a combination of soil, sand, larger rocks, and pebbles on the top of an elevated board. Have a container to catch the run-off. Pour water on the top of the board. What moved the farthest? What is in the middle? What moved the least? What are the reactions of the children to the question, "What will happen if there is a gentle rain? a heavy rain? Which rocks would move the easiest?" Can the children make any conclusions concerning water and rock movement?

18. **Leading Question:** What is the basic ingredient of soil?

Materials: Rocks, white paper, reading or magnifying glass, tripod magnifier, soil

Procedure: Give a number of children two rocks and a piece of white paper. Have them rub the rocks together and describe what has fallen on the white paper. Ask the children for suggestions as to what instruments they might use so they can see the bits of rock more clearly. Have all the children observe closely what is on the paper. Put a sample of soil on the white paper beside the rock particles. Compare the soil sample with the rock particles. Are there any pieces of rock in the soil? Can anything else be found in the soil? Describe other materials found in the soil.

19. **Leading Question:** Is soil made only of particles of rock?

Materials: Rocks, soil, white paper, flower pots or milk containers, radish seeds

Procedure: Using the previous experience, have the children plant radish seeds in two containers - one containing soil, the other bits of rock. Encourage predictions as to whether plants will show the same growth in both containers or whether there will be a difference in the rate of growth. Water, and care for each container in the same way. What results can be seen when checked daily? Are the children able to come to any conclusion as to the contents of which container is best for growing plants. Compare predictions with results.

Note to teacher: The children should be made aware of the fact that particles of rock are basic but not the only ingredients of soil.

20. **Leading Question:** Do soils differ or are they the same?

Materials: Soils from mountains, rivers, creeks, a road, a garden, potting soil, sand, containers

Procedure: Distribute a small amount of soil in a container to a number of children. Encourage children to observe the soil and guess how it will feel when they put their fingers into it. Perhaps they will need help to get started, but soon they will want to describe how the soil feels. Encourage the use of descriptive words such as: sandy, cool, dry, greasy, sticky. Did the soil feel the way the children thought it would feel? How many children guessed correctly concerning the feeling of the soil? Ask other children to examine the soil. Are all soils the same color? Which soils are the most dark, light, red, brown, yellow or tan? Classify each soil according to color.

21. **Leading Question:** What do earthworms do to the soil?

Materials: Soil, containers such as clear plastic boxes or glass jars with lids, earthworms, black construction paper, scotch tape

Procedure: Ask for volunteers to bring in soil and earthworms. Have some clear plastic boxes or glass jars ready to receive the earthworms and soil. Place worms and soil into the containers. Watch worms burrow into the soil. Put lids on containers. Scotch tape black construction paper around the jar. Have children predict what will happen. Take off the construction paper the next day. Observe what changes have taken place. Re-tape the black construction paper around the container. The next day again observe what has happened. Were the predictions correct?

Note to teacher: Return earthworms to the soil after the experiment is completed. Why?

22. **Leading Question:** How can we conserve the soil?

Materials: Soil, grass seed, two pans at least one inch deep, hand fan, electric fan

Procedure: A. Put soil into the two pans. Plant grass seed in one pan. When grass has grown to about an inch, take both pans outdoors. Ask the children to anticipate what will happen if they gently fan each pan. Have the children take turns gently fanning the pans. Note what happens to each pan. Next, have the children take turns blowing on each pan. What happens? If any soil is left in the one pan, turn the electric fan on it. Use the electric fan in the same manner on the pan with the grass in it. Discuss what has happened. Are the children able to draw any conclusions from this demonstration? Are there any areas around the school where this has happened? Do the children know of any other areas where this has happened? How could the blowing away of the soil have been prevented?

23. **Leading Question:** How can we help to conserve the soil?

Materials: Soil, grass seed, two pans at least one inch deep, water, sprinkling can, a board

Procedure: B. Put soil into both pans. Plant grass seed in one pan. When the grass has grown to about an inch, have a child try this demonstration: Elevate one end of both pans on a board at about a 30° angle. Have the children hypothesize as to what will happen when the child pours the same amount of water on each pan. Tell the child to use the sprinkling can to sprinkle the water on each of the pans. What has happened to each of the pans? Were any of the children correct? Are the children able to relate this small happening to what occurs in nature when there is a heavy rainstorm?

24. **Leading Question:** How do plants and roots of plants affect rocks?

Materials: Rocks with plants growing on them, hand lens, tripod magnifier, pictures of rocks with lichens on them, pictures of rocks being split by trees, opaque projector

Procedure: Ask children to see if they can find rocks with plants growing on them and to bring them to school. Carefully remove the plant from the rock. Using the hand lens or any other magnifying glass, observe the area where the plant was growing. Has any change taken place on this part of the rock? Look again at the part of the rock where the plant was growing and at the roots of the plant, using the magnifying glass. Look at the pictures using the opaque projector. What are the children's reactions to the pictures? What do the children think will happen to the rocks being split by trees? Are there any rocks in the local area which show signs of this having happened to them?

25. Leading Question: Are people able to see all of the rocks on the earth?

Materials: A large globe, visual aids and the projector needed for them

Procedure: Begin the lesson with a discussion about the earth. Have the children speculate as to whether there is more land or water on the earth. Use a large globe to identify the land and water areas. Which covers the greatest amount of space? Pose these questions:

> Do you think we can see all the rocks on the earth?
> Are there any rocks covered by soil? How do you know?
> Are there rocks at the bottom of lakes? rivers? creeks? oceans?
> How do we know there are rocks at the bottom of the water?

After using the visual aids, again ask the preceding questions to find out if there is a change in the minds of some of the children.

DIGGERS TO DIVERS

Rocks - Then and Now

Grade 3

Earth - Its Formation

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
There are many different theories on the origin of the earth.	1
The four layers of the earth are atmosphere, hydrosphere, lithosphere, and centrosphere.	1,2
The lithosphere, or "rock sphere" is composed of the crust, mantle, and core.	2
Visual features of the crust include continents, mountains, hills, plateaus, plains, and islands.	36
Mountains are upward projections of rock and are formed in different ways.	3
Rocks originate in three ways: from the cooling of molten materials, the cementing of fragments, or the changing of existing rock forms.	1,6,25,38
Note to teacher: These rocks are known as igneous, sedimentary, metamorphic. (Grade 3 will make a study of sedimentary rocks.)	
A mineral is a non-living matter found in the earth with its own crystal size, shape, and color.	6,38
The forces of construction and destruction, are constantly causing changes of the earth's surface. (volcanoes, glaciers, bending, etc.)	3,4,5,45

DIGGERS TO DIVERS

Rocks - Then and Now

Grade 3

Soil - Its Properties

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Soil is the top layer of the ground and is composed of weathered rock, plants, animals, air, and water.	7,13,15,17,21
Particles of clay, humus, and loam make up the soil.	7,13,15,17,21,41
Topsoil is closest to the earth's surface and is most suitable for growing plants.	13,14,15,21,41
Sandy soil originates from sandstone.	13,16,17
Soil in different locations varies in composition.	13,14,16
Soil is constantly being changed through gradual processes. (weathering and erosion)	7,8,9,10,11,12,13,16
The movement of rocks and soil grind together and eventually become exceedingly fine particles of soil.	10,11,13,16,17,18

DIGGERS TO DIVERS

Rocks - Then and Now

Grade 3

Sedimentary Rocks

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Deposits of fine soil gradually build up land.	11,13,17,19,23,24
Organic and inorganic fragments are carried by various agents to the bottom of a body of water. The settlement of the deposit in the water begins the formation of a sediment.	11,18,19,23,24,26, 27,31,32,34
Pressure and cementing agents produce sedimentary rocks. This process takes millions of years.	23,25,26
The kind of rock depends on the type of original sediment.	23,26
Conglomerate is composed of heavy gravel and pebbles cemented together.	23,24,26,38
Sandstone is composed of sand cemented together.	23,24,26,27,28,38
Clay is a sedimentary material composed of very fine grains from various types and colors of rocks.	23,24,35,38
Shale is a soft rock, formed in sheet-like layers, which is made up of fine particles of rock.	23,24,26,28,38
Limestone is formed from the skeletal remains of ocean animals.	23,28,29,30,31,32, 33,38
Coal is a sedimentary rock resulting from the carbon remains of plants buried in water, and submitted to heat and pressure.	38

DIGGERS TO DIVERS

Rocks - Then and Now

Grade 3

Uses of Rocks and Minerals

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Rocks and minerals have many functional and decorative uses.	37,38,40,42,43,44
Much of the earth's matter must be processed before it is used.	37,38,40,42,43,44

DIGGERS TO DIVERS

Rocks - Then and Now

Grade 3

ACTIVITIES

1. Leading Question: What are some of man's ideas on the origin of the earth?

A. Materials: Reference books from the library

Procedure: Use the school library to discover some of the major theories on the origin of the earth. Read and report to the class. You may want to report on the theories of Pierre Simon Laplace, Thomas Chamberlin, Forest Moulton, and Carl von Weizsaker.

Note to teacher: For background information, you may find the theories of the following men in a book in your Science Room: Gerald S. Craig, Science for the Elementary Teacher, Ginn & Co., 1958.

1. Immanuel Kant's Hypothesis
2. Pierre Simon Laplace - Mebular Hypothesis
3. Thomas Chamberlin - Planetesimal Hypothesis
4. James Jeans and Harold Jeffreys - Gaseous - Tidal Hypothesis
5. Harold Jeffreys - Collision Hypothesis
6. More Recent Hypothesis - (Ideas about the formation of the earth are always changing. Watch the newspapers and magazines for reports of newly advanced opinions.)

B. Materials: The Physiographic Relief Globe (From the Central Science Materials Library)

Procedure: Examine the earth's physical features - mountains, rivers, plains, and islands, on the Physiographic Relief Globe. Open the glove at the equator line and examine the interior of the earth. Examine the lithosphere, or the part representing the solid part of the earth, - the earth's crust, the thick mantle, and the inner and outer cores. How much of the earth is crust? Which part of the interior of the earth is thickest? Which part of the earth do you think man knows the most about? Why?

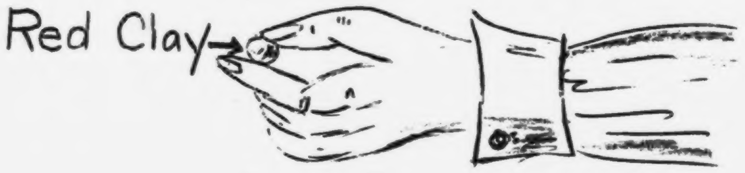
Note to teacher: The Physiographic Relief Globe is an accurate relief model featuring a complete view of the earth's exterior and interior. The globe is designed to be opened at the equator, enabling the pupil to explore the four parts of the interior consisting of the crust, mantle, outer core, and the inner core.

The outermost layer varies in thickness from seven to twenty miles. The mantle is believed to consist of solid hot rock 1800 miles thick. The complete core is believed to be molten metal, compressed into a solid form, because of the weight of the earth, and is 3100 miles thick.

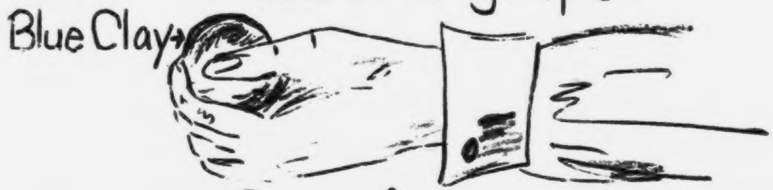
2. **Leading Question:** What is the interior of the earth like?

Materials: Plasticine Clay (two colors), aluminum foil, sharp knife

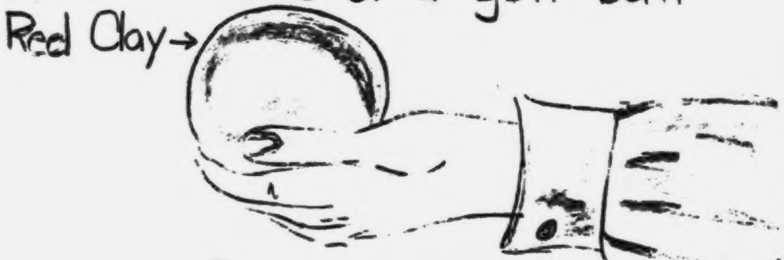
Procedure: Make a ball of red clay the size of a grape for the inner core of the earth. Mold a piece of blue clay around the first ball, until it is the thickness of a golf ball to show the outer core. Take another piece of red clay and shape it around the ball, until it is the size of a grapefruit, for the mantle of the earth. Finally, cover the complete ball, with a large piece of aluminum foil, to represent the crust of the earth. Use a very sharp knife to cut the ball in half. Look carefully at the outer crust. Is it very thick compared to the other layers of the earth? Name the different layers of the earth. Which layer do we know the most about? Why? Do we know anything about the other layers of our real earth? Why?



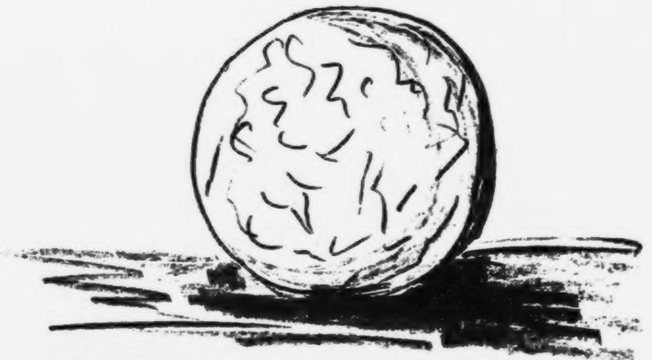
Size of a grape



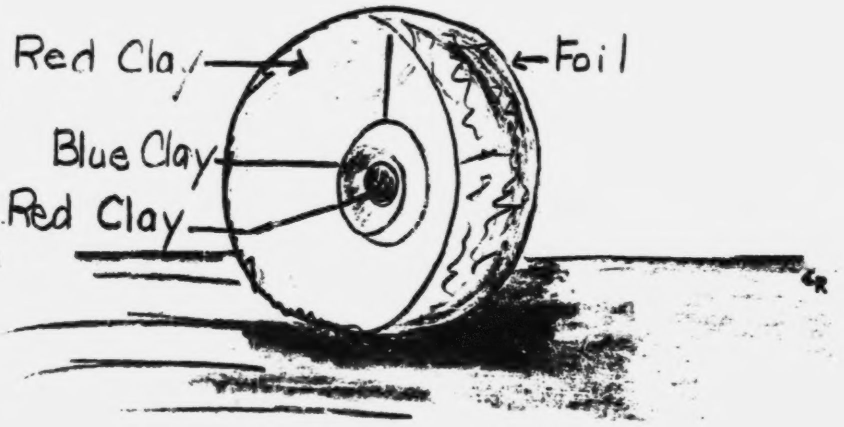
Size of a golf ball



Size of grapefruit



Covered with aluminum foil



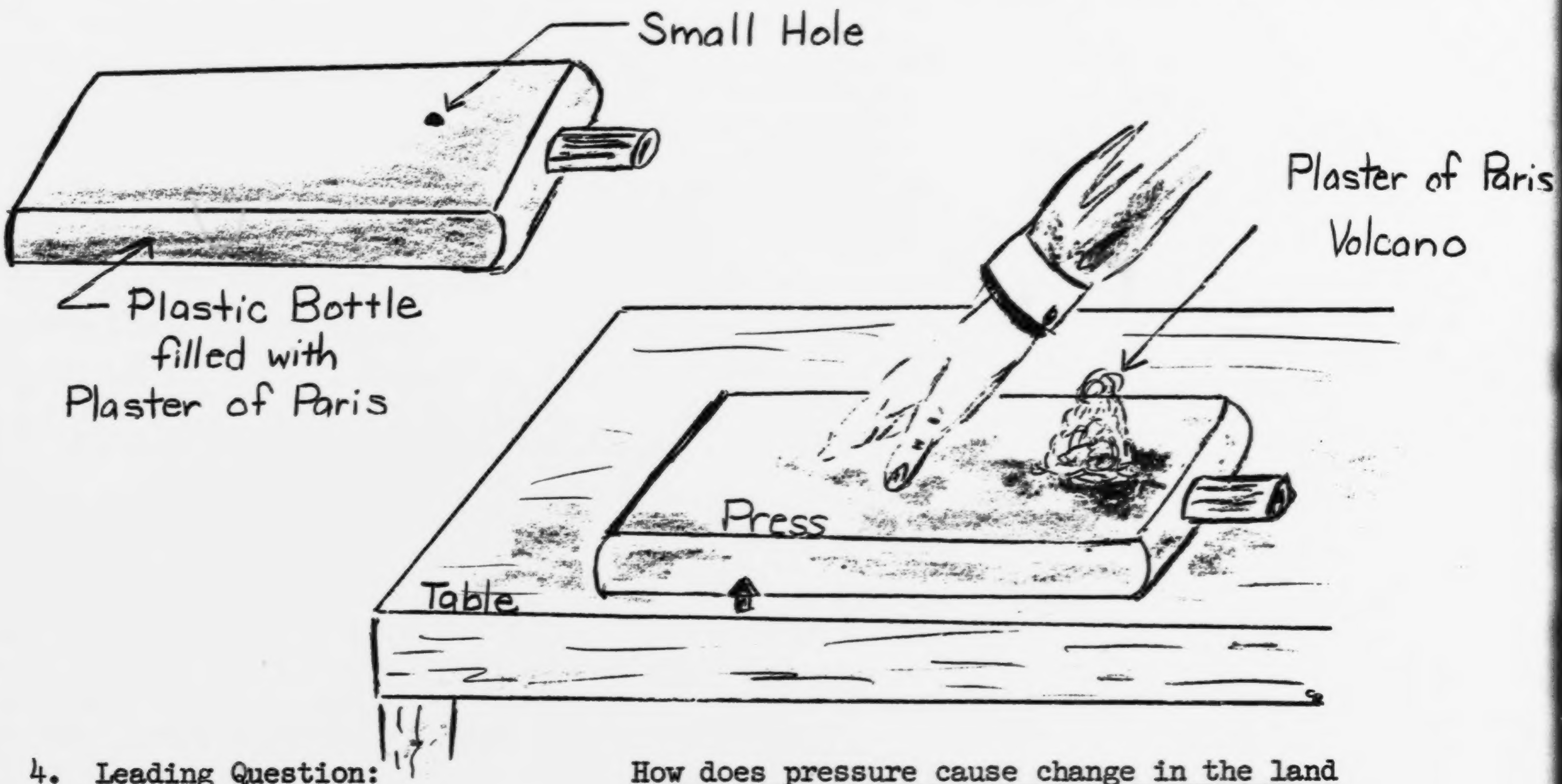
Ball with slice cut out.

3. **Leading Question:** How are surface changes caused by molten liquid within the earth?

Materials: Plaster of Paris, water, flat plastic detergent bottle, large tin can, paper cup, compass

Procedure: Mix a batter of plaster of Paris and water, to a consistency of thick pancake batter, in a large tin can. Bend the top of the can to form a spout. Pour the batter into a plastic detergent bottle. Screw the lid on the bottle. Lay the bottle flat on its side. Punch a small hole in the side of the bottle with a compass point. Press firmly on the side of the bottle until the lava flows out of the hole. As pressure is applied, place a small paper cup over the lava flow to form a volcanic mountain. Allow the plaster of Paris to harden into a volcano. What makes it possible for the liquid batter to break through the side of the bottle? In which directions are pressures applied to the bottle? What will happen the next time there is a lava eruption?

Note to teacher: Protect eyes in event you have a large "eruption".



4. **Leading Question:** How does pressure cause change in the land surface?

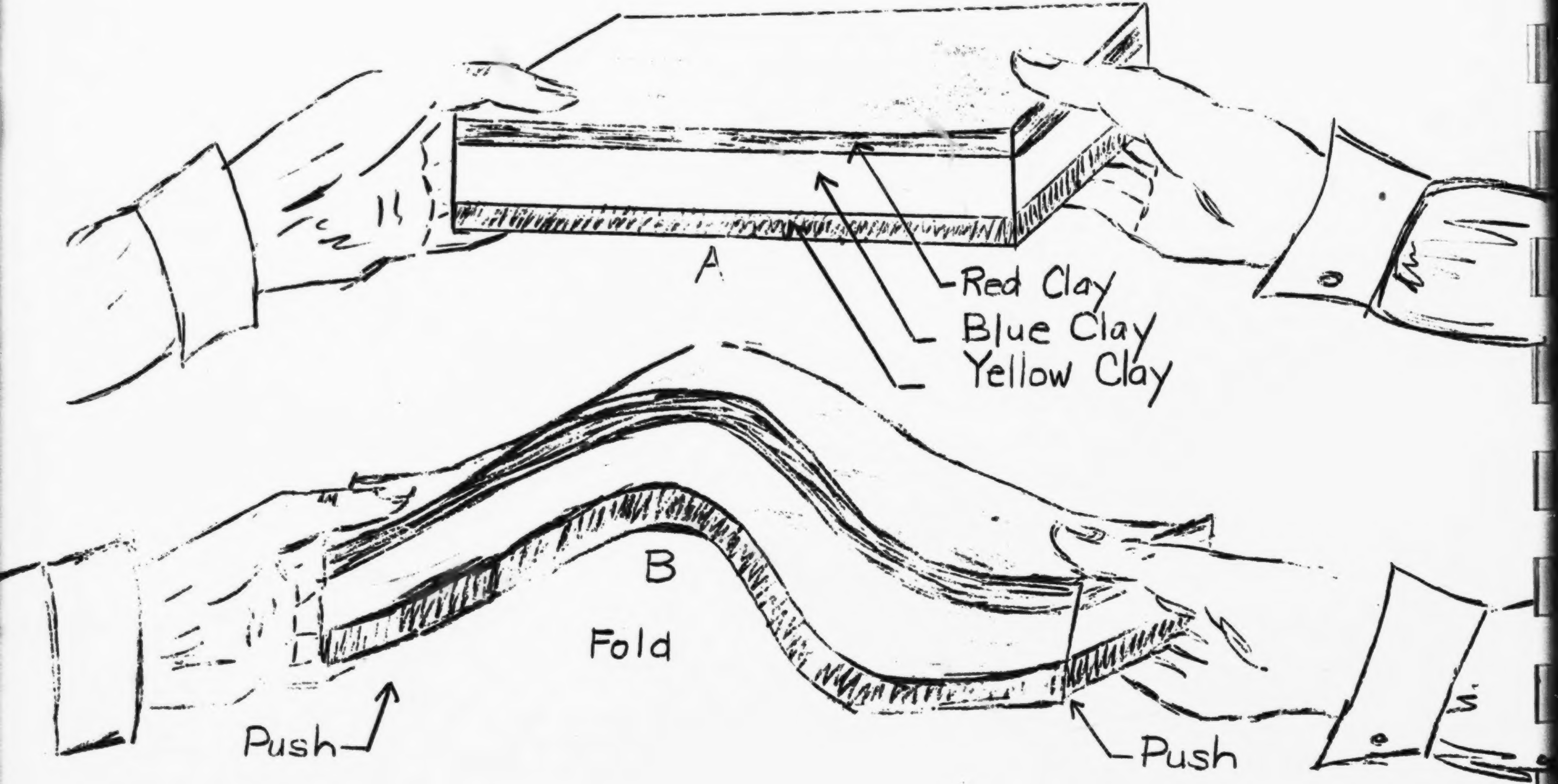
Materials: Several colors of modeling clay

Procedure: Roll out the modeling clay to make uniform sheets. Arrange the sheets in layers with colors alternating. Consider each layer of clay as a representation of a different layer of rock.

Push on the two ends. What does the pushing represent? What happens to the clay?

Note to teacher:

This is called a "fold" which is the bending of the earth's surface. The next step will result in "faulting".



5. Leading Question:

How do glaciers effect the earth's surface?

Materials:

Cardboard milk carton, a long pan, mixture of sand, soil, gravel and pebbles, 9 x 12" flat of clay, water and area for freezing

Procedure:

Put a handful of sand, soil, gravel, and pebbles into a milk carton and add enough water to cover the mixture. Freeze this solution. Add another handful of the mixture, cover with water, and freeze again. Continue this addition and freezing process until the carton is half full.

Peel the container from the frozen matter. Lay a sheet of clay in the bottom of a long pan. Move the block of frozen material slowly over the clay. How does the block effect the clay?

Leave the block of ice on the clay at one end. Tilt the pan slightly with a board or book and let the ice melt. What kind of a deposit is left on the clay?

What does the clay represent? What does the frozen material represent? How do the two react to each other?

6. Leading Question: Since rocks are made up of crystals, how are the crystals formed?

A. Materials: Drinking glass, string, pencil, large nail, water, magnifying glass, (sugar, salt, alum, borax or Epsom salt)

Procedure: To observe the process of crystal formation, dilute one of these materials (sugar, salt, alum, borax or Epsom salt) in a glass of water. Fasten a nail to a short piece of string and hang the string from a pencil which is laid across the top of the glass. Observe the gradual crystal formation on the nail and the string. Examine the crystals with a magnifying glass.

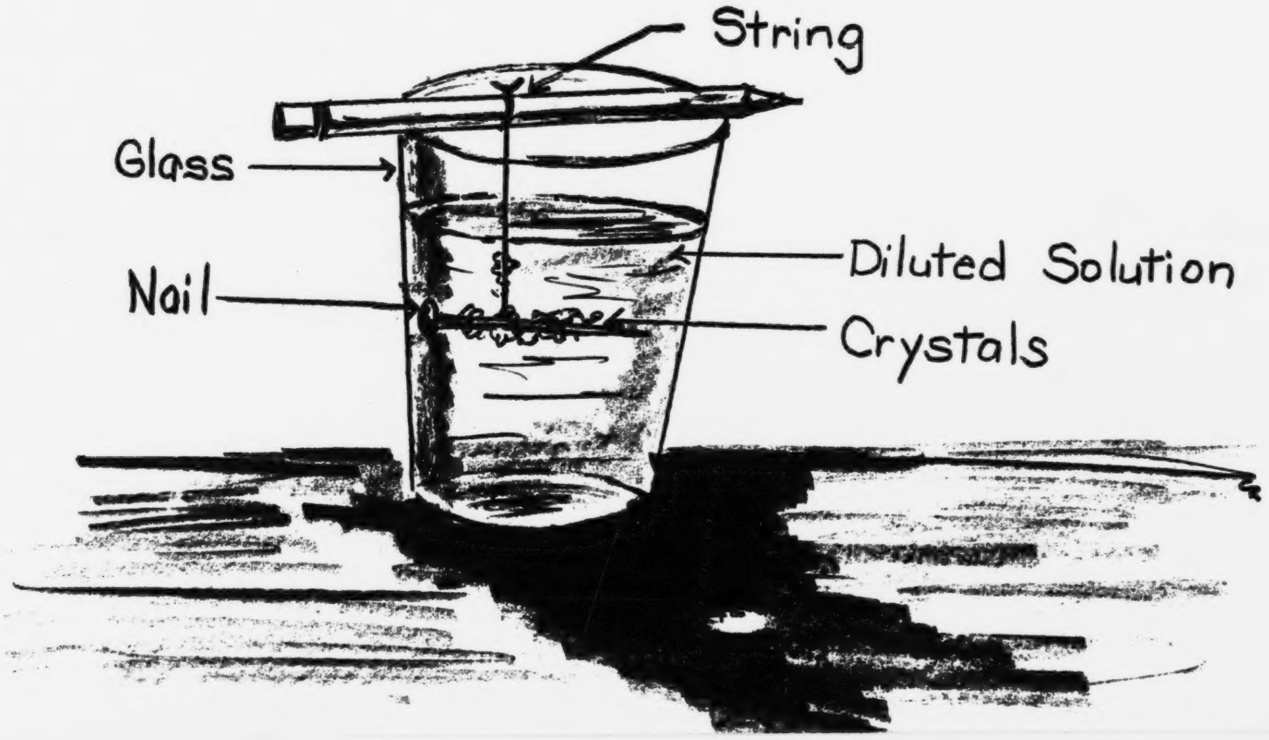
B. Materials: Magnifying glass, stereo-microscope

Procedure: Observe some crystals in different kinds of rock by using the stereo-microscope or a magnifying glass.

C. Materials: Limestone, hammer, piece of old cloth, magnifying glass

Procedure: Pulverize some sedimentary rock with a hammer. Wrap the rocks in a piece of old cloth, for safety, before striking them. Now examine the crystals with a magnifying glass.

Note to teacher: Most crystals in rock are only partially visible. Not free to form in solution as on the nail, the crystals are half-hidden within the rock makeup.



7. Leading Question: What happens when water freezes in a crack of a rock?

A. Materials: Ice cube tray, water, freezer of a refrigerator

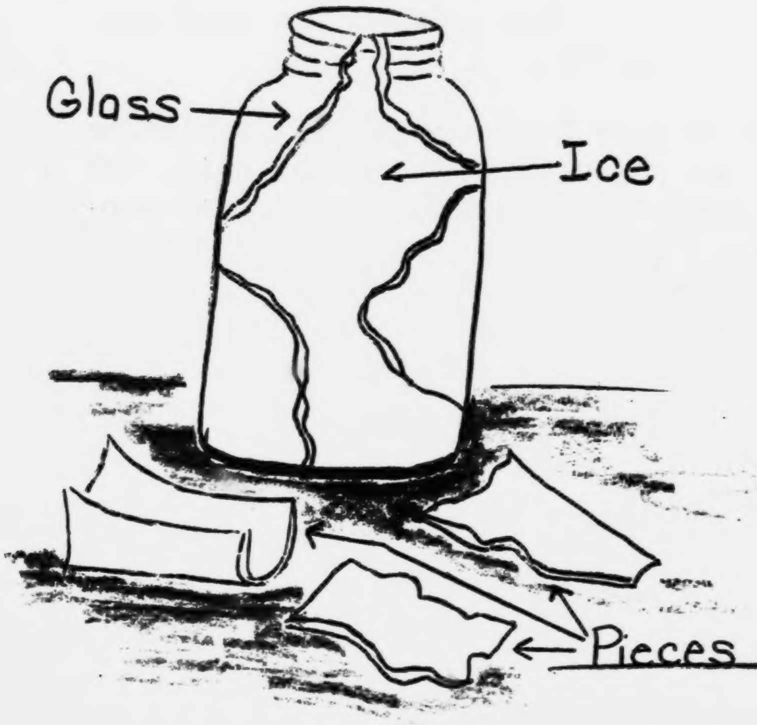
Procedure: Fill an empty ice cube tray with water to the very top. Put the tray into the freezer of your refrigerator until the water freezes. Take it out of the refrigerator and examine the ice. Does the ice take up more or less room than the water did? How can you prove it?

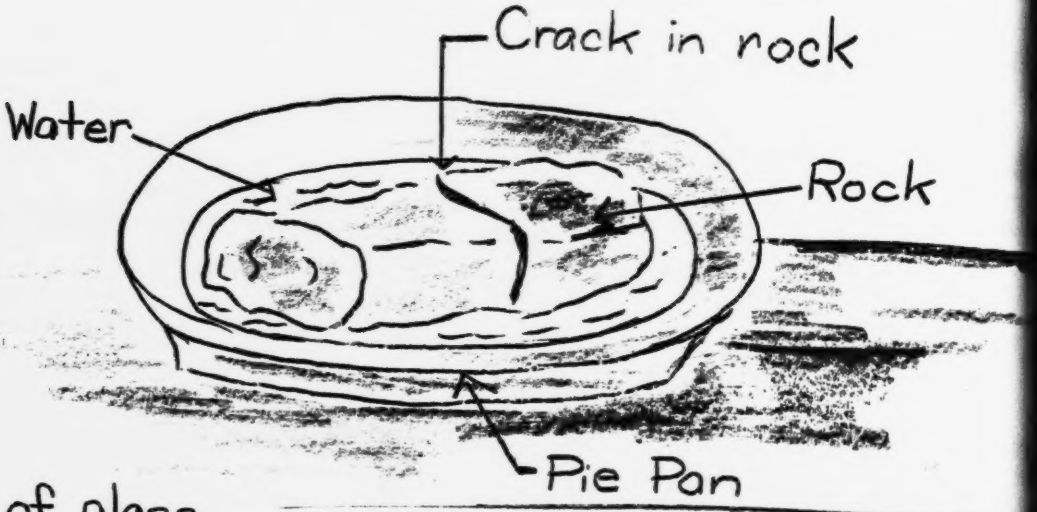
B. Materials: Jar, with screw top lid, paper bag, freezer

Procedure: Fill a jar with water and screw on the lid tightly. Put the jar into a paper bag and place it in a freezer until the water turns to ice. Take bag out of the freezer and peep into the bag. What happened to the jar? Why? What happened to the water in the jar? What does this prove?

C. Materials: A rock with a crack, water, pie pan, refrigerator freezer

Procedure: Find a rock with a crack in it. Pour water over the rock until it has seeped into the crack. What will happen to the rock if you freeze the water? Place the rock in a pie pan and partly fill it with water. Place it in the freezer and see what happens. Take it out of the freezer and wait until the ice melts. Examine the crack in the rock. What has happened to the rock? Try this process several times and make some observations as to the effect of ice in a crack of a rock.





8. **Leading Question:** How do plants effect rocks?

Materials: Shoe box, plaster of Paris, lima bean seeds, jar, paper towels, water

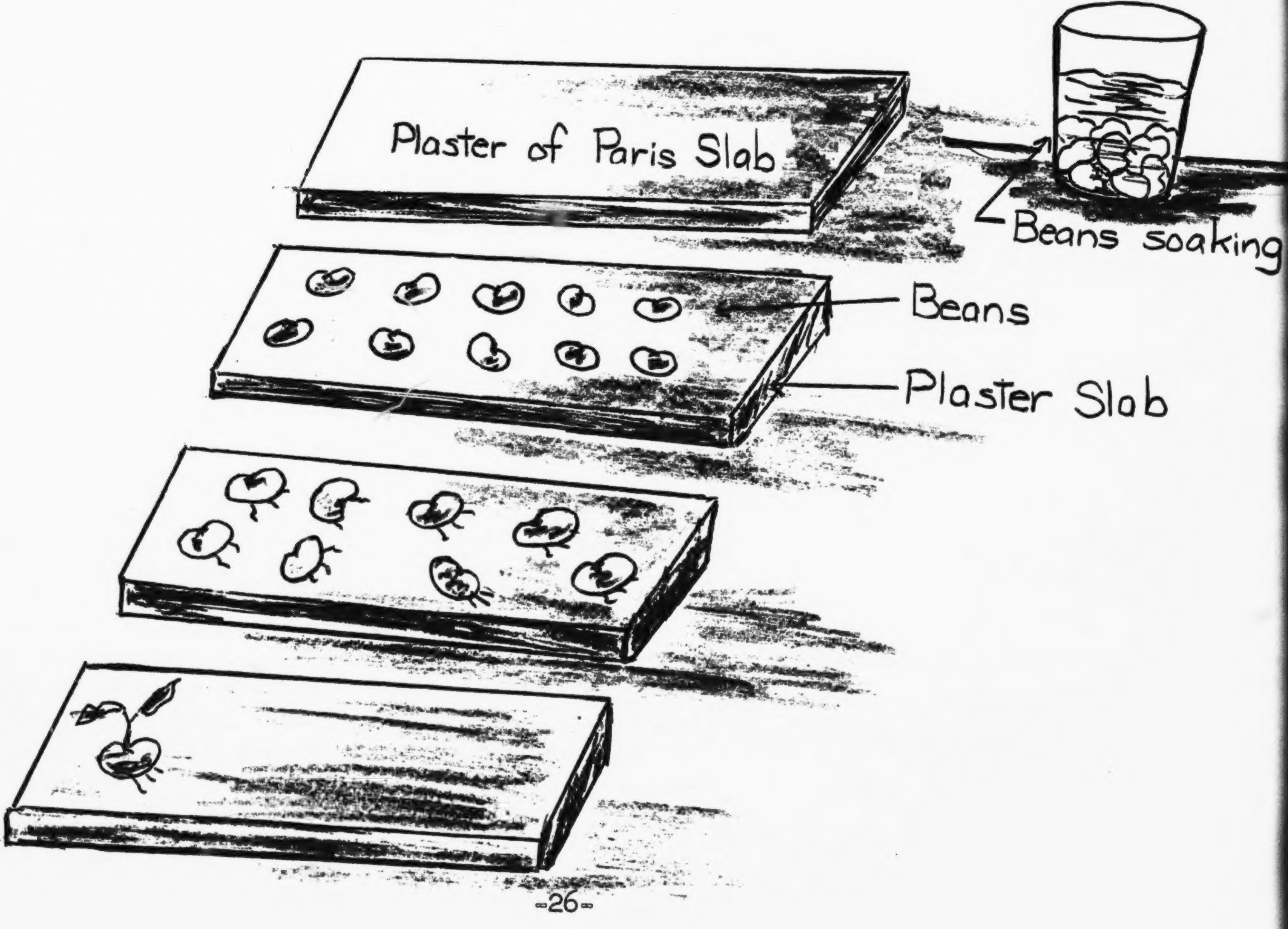
Procedure: Make a plaster of Paris slab by mixing plaster of Paris with water until the mixture resembles pancake batter. Pour this into a shoe box lid. Let it dry.

On the dry plaster slab, lay some lima bean seeds that have been saturated with water. Cover the seeds with layers of wet paper towels. Keep the towels moist for about a week.

After a week, remove a few of the seeds from the slab. What has happened to the plaster of Paris? Remove a few sprouts every two days and examine the slabs carefully. In order to compare the growth, record the date of removal next to bean imprint on the slab.

How do the lima beans effect the plaster? Why do the plant roots dig into the rock or plaster? What does the digging of the plant roots do to the rocks?

Observe places in nature where plants grow on rocks.



9. Leading Question: What happens to rocks when they are heated and cooled many times?

Materials: Two thin drinking glasses, pie pan, hot plate burner, ice cubes, sauce pan

(1) Procedure: Heat some water in a sauce pan until it boils. Place some ice cubes in a glass until the glass is very cold. Remove the ice cubes. Place the glass in a pie pan and pour the hot water into the cold glass. What happens to the glass? Why?

(2) Procedure: Pour some warm water into a glass and keep it there only long enough to warm the glass. Pour out the warm water and quickly fill the glass with ice cubes. Does anything happen to the glass? Why?

What do you think will happen to a rocky mountain as it is heated by the sun in the daytime and cooled by the night air, time after time?

10. Leading Question: How are pebbles worn by stream action?

Materials: Brick or slate, quart jar with screw lid, filter paper, crayon, Overhead Projector and screen, hammer, a piece of cloth (old)

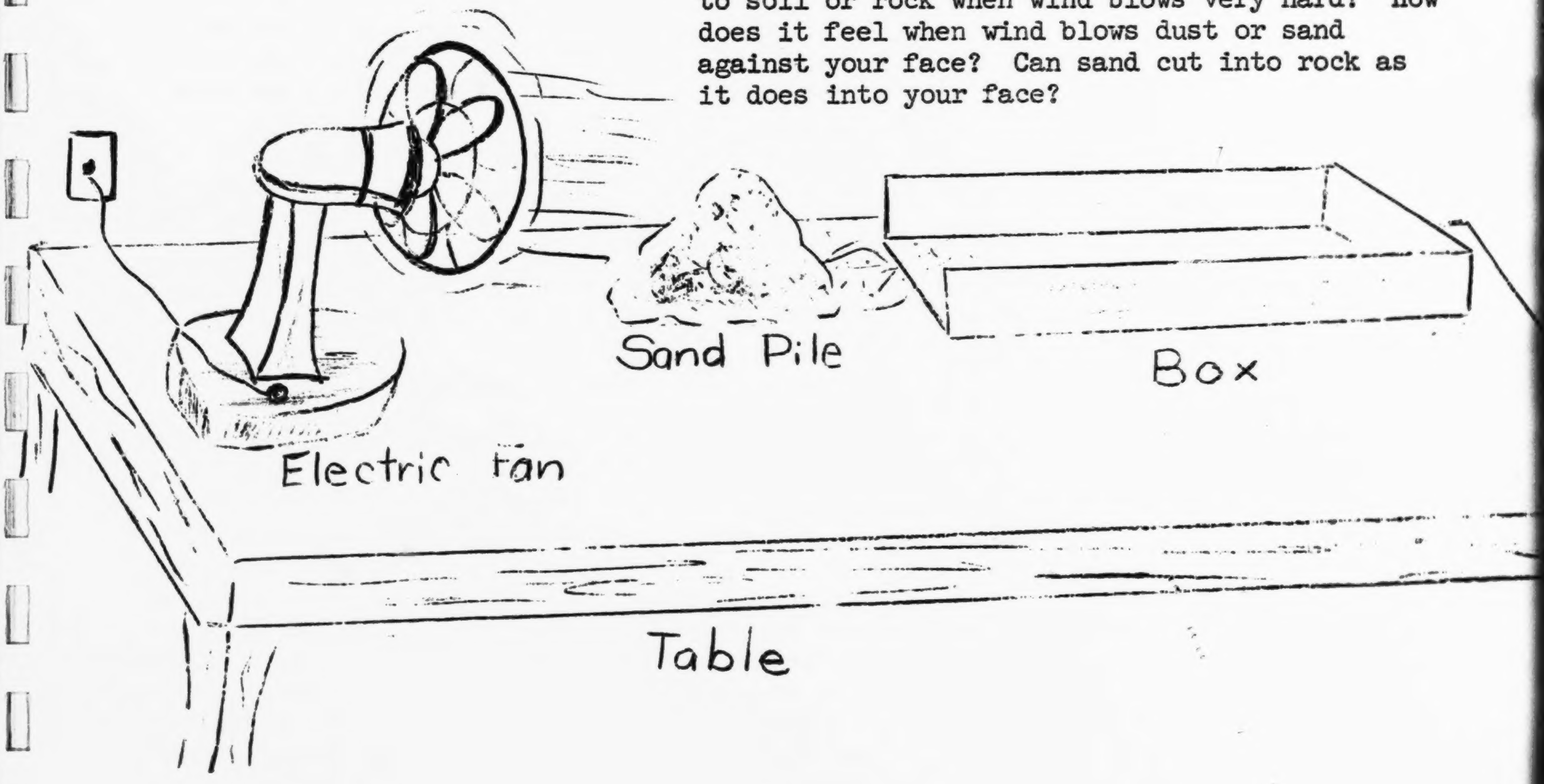
Procedure: Break a piece of slate or red brick into sharp pieces about an inch across. To break this material, wrap it in a piece of cloth, for safety, and hammer until the slate or brick is broken into pieces. Put several of these pieces into a strong jar, half-filled with water. Mark one piece of brick or slate with a colored crayon so that you keep an accurate record. Before placing the marked piece in the jar, place it on a transparency and project it on the screen with the Overhead Projector. Trace around it with a magic marker or crayon in order to remember the original size. Each time it is removed from the jar, after shaking, mark it with a crayon again and project it on the screen. Trace it again and compare it with former drawings. Allow each child to take his turn in shaking the jar vigorously. Place the jar in a strong paper bag, for safety, before the shaking begins. Remove the jar from the bag occasionally in order to examine the contents. What is happening to the water? To what natural process does the shaking of the slate or brick in the water correspond? How do the shapes of the pieces compare with pebbles in a stream?

Keep a "time-lapse" record. Record the number of times the jar was shaken by each pupil. Add to the record each time the jar is closed and shaken again. When the experiment is completed and the records are filled in, pour the water and materials over a filter. Examine the remains of the brick or slate. Appraise the results of the experiments in terms of stream action on pebbles.

11. Leading Question: What effect does wind have on soil and rock?

Materials: Newspaper, cardboard box, sand, ruler, pencil, electric fan

Procedure: Cover a table with newspaper. Cut one end from a cardboard box. Place the box at the end of the table with the open end facing the center of the table. Pile some sand near the open end of the box. Place an electric fan near the other end of the table. Before turning on the fan, measure the height of the sandpile and draw a line, on the newspaper, around the base of the sand pile. Now turn on the fan at low speed and point it toward the sand. Leave the fan on for several minutes. Stop the fan and again measure the height of the pile. Also measure the height of the newly formed pile in the box. Then turn on the fan and keep it on for several minutes. Keep a time record and a a height record of the changed piles of sand. What caused the sand to move? What will happen to soil or rock when wind blows very hard? How does it feel when wind blows dust or sand against your face? Can sand cut into rock as it does into your face?



12. Leading Question: What evidence of change in rock and soil can be detected at the present time?

Materials: None

Procedure: Plan, and take a field trip in the vicinity of the school. Before taking a trip, allow the children to state what they expect to see. How are people causing changes in the surface of the land? What signs of weathering and erosion are evident? At an excavation, can you see the newest soil formation? Of what is it compared?

Note to teacher: Be sure the children discover soil that has been moved in recent rains, gullies, roots of trees and plants, cracks in pavements and gutters, etc.

13. Leading Question: How do rocks form soil?

Materials: Natural stones, man-made stone (bricks or concrete fragments), sheets of paper

Procedure: Gather soft rocks like shale or limestone and some building bricks or concrete fragments. Rub the pieces of natural stone together over a sheet of paper. How long does it take to rub off even a few particles? Rub the pieces of man-made stones together over a sheet of paper. How long does it take to rub off a few particles? Rub a piece of natural stone with a piece of man-made stone. How long does it take to rub off a few particles? Which particles come off first, natural or man-made stone? Compare which stones form soil most rapidly, natural with natural, man-made with man-made, or natural with man-made.

Try to predict whether man could make soil if a shortage arises. How could this be done? What factors would need to be considered? What would have to be added to man-made soil in order to make it possible to grow plants?

14. Leading Question: What are the layers of soil?

Materials: Field trip (near a hillside), spade, measuring stick, paper and pencil

Procedure: At the top and bottom of a hills slope, dig holes about the size of post holes. Compare the depth of topsoil at the top and bottom of the slope at each hole. Find the dividing line between the topsoil and subsoil. Compare the topsoil and subsoil in appearance, texture, contents, etc. How does each type of soil help man? Why should man know the difference between topsoil and subsoil?

Note to teacher: Be sure to have soil replaced in holes as an example of conservation.

15. **Leading Question:** What does topsoil contain?

Materials: Heavy paper bag or carton, space, ruler, large sheet of white paper, magnifying glass, screen, bottles

Procedure: Either take a field trip to get soil or have the children bring in some soil. Dig up soil from an area of one square foot and two or three inches deep. Place this in a bag or carton. Indoors, gently spread out soil on a large white paper. With the aid of a magnifying glass, look for living specimens in separate bottles with lids that have air holes. Sift the soil through a piece of window screen.

How many different living and dead specimens can you find? Can you classify them? What non-living matter can you find? Can you classify them? Why is it significant to know that the soil contains so much extra matter? Think about a comparison of the amount of matter in the one square foot to 1 acre, 10 acres, 100 acres. How is this important to man?

16. **Leading Question:** Are all soils alike in composition and color?

Materials: Samples of soils from different places (from a brook, dirt road, garden, woods), baby food jars, water

Procedure: Secure a set of baby food jars. Put a different kind of soil in each jar. Fill each jar half full and add water. Shake the jars until the soils are mixed with the water. Allow the soils to settle in the water. Examine the soil in each jar. Do they look alike? Are they all the same color? Do they feel alike? What happens to the plant material in the soil? What happens to the rock material? Arrange the jars in a row according to their lightness or darkness of color. Label each jar according to the place where the soil was secured.

17. **Leading Question:** Are all soil particles the same size?

Materials: Several large glass jars with lids, soil samples, cardboard, siphon tube

Procedure: Obtain soil from different places. Partially fill each of several jars with equal amounts of soil that has come from different places.

Add water. Leave a small air space at the top of each jar. Secure lids tightly. Shake the jars vigorously and let them stand for several hours. Observe, to see what happens, after the particles have settled. By holding a cardboard against each jar, diagram and label what is seen. Explain why this occurs. Siphon off the water through a tube and examine particles from each layer under a magnifying glass. What types of soil are seen? What kinds of organic matter are present? Compare how the layers feel in textures and sizes. How do the different sizes of soil particles affect land? How do these differences affect man?

18. **Leading Question:** How does water carry soil?

Materials: Jars, water from a stream, water from a gutter

Procedure: A. After a heavy rain, collect jars of water from a stream and from the street gutter. Let the water settle. What happens? What does this prove? Compare the sediment that results from the stream water with gutter water. What would be needed to make these sediments into rocks? How would the resulting rocks compare?

B. After the heavy rain, also explore the school grounds for evidence of soil transported by water.

Note to teacher: Sediment is often deposited along walks, driveways, and areas of the lawn.

19. **Leading Question:** How does rain affect the soil?

A. Materials: Soil, sod, eight trays (pans or wooden boxes), bean seeds, stones or wood

Procedure: Set up trays, pans, or wooden boxes so that two have barren soil. Two others should have sod. Another two should have some plants in barren soil. The last two should have plants growing in sod. On a rainy day set the prepared samples outside. Lay one of each sample flat on level ground. Next to these, or behind them, mount the remaining samples on wood or stone to create a slope. After the rain, observe what has happened. Compare the degree of erosion in the different types of samples. Compare the amount of erosion of the level and sloped samples. What conclusions can you draw from this experiment that are important for man to use land wisely?

Note to teacher: Prepare this with the children ahead of time to be used on a rainy day. Plants may be bean plants grown by students.

Procedure: Look around the school for effects of the rain. How did the rain affect the walls of the building? Observe and compare grassy and bare spots near the building, close to pavements, near trees, or in open spaces.

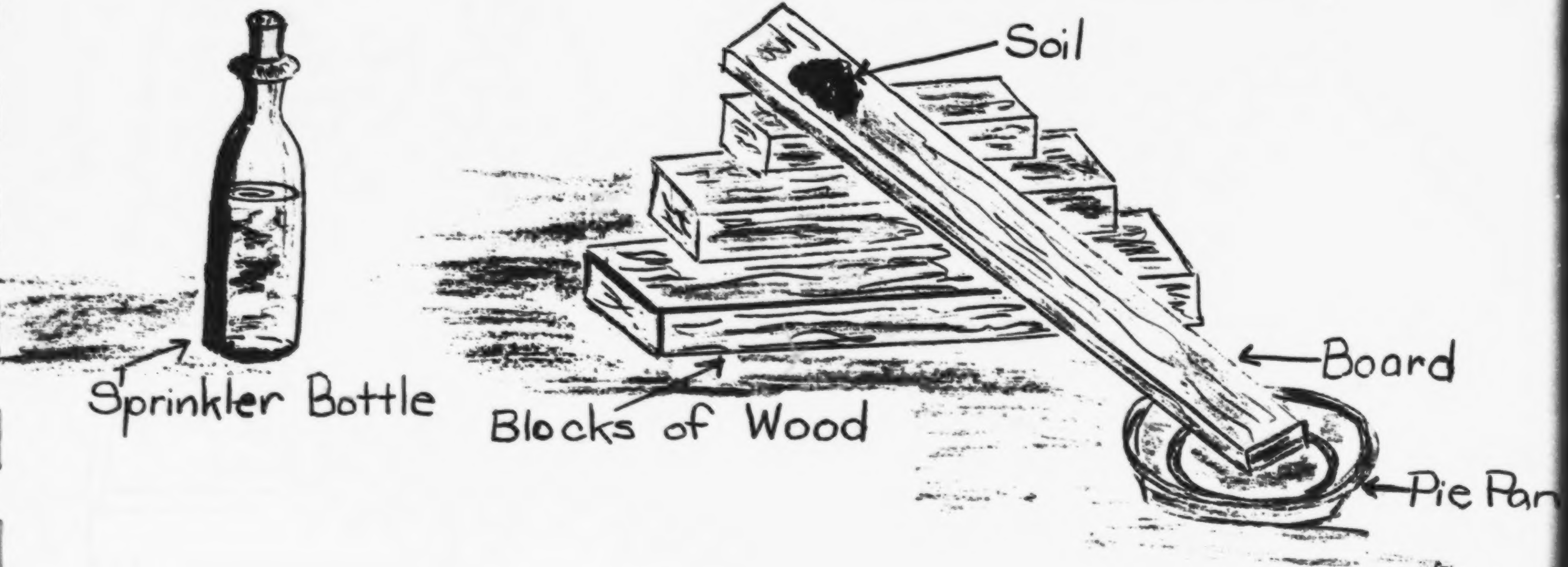
B. Materials: Jar lid or saucer, soil, medicine dropper, yard stick, large sheet of paper

Procedure: Set a jar lid or saucer in the center of a large sheet of paper. Put some soil in the lid or saucer. With a medicine dropper release a few drops of water on the soil from about a yard above the soil. What happens?

Put an obstacle such as paper, pencil, or a blade of grass in the path of the falling drops. What happens? How does this compare to the first time? Relate this experiment to nature by thinking about soil without a cover and soil covered by plants. How can man prevent erosion?

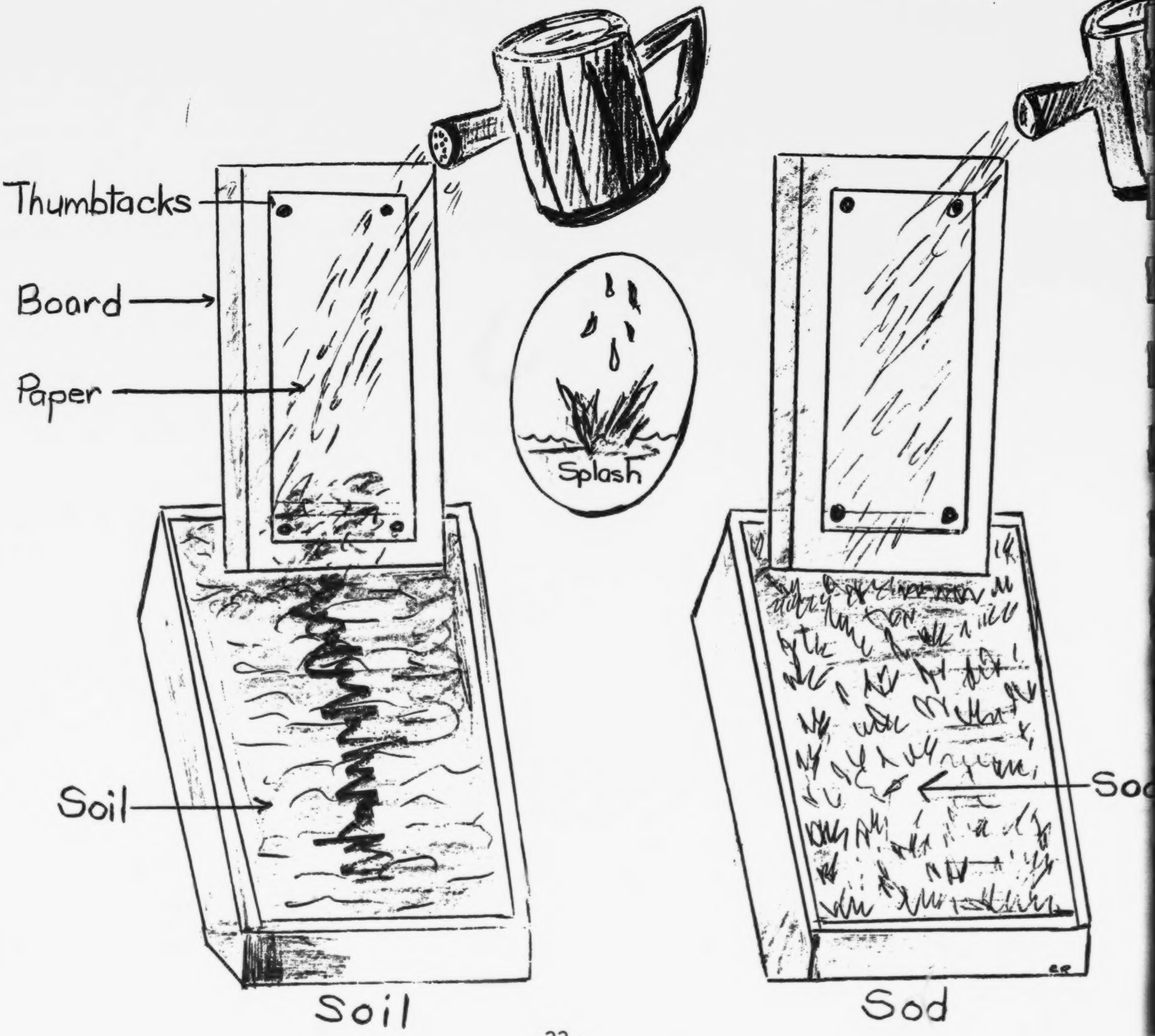
C. Materials: Pie pan, soil, small board, bottle with sprinkler top, water, several blocks of wood

Procedure: Place several blocks of wood on a pile. Place a board in the position of a hill with the lower end in a pie pan and the upper end on the pile of blocks. Spread some soil on the high end of the board and pat it down. Fill a sprinkler bottle with water. Sprinkle the ground at the top of the hill. What happens to the soil? Why? Where does the water go? How does the water appear after it reaches the pan? What would prevent soil from being carried down hill?



D. Materials: Two boards (2-1/2 feet long and 6" wide), white paper, thumbtacks, sprinkling can, two boxes

Procedure: Use two boards (2-1/2 feet long and 6" wide) as splash sticks. Thumbtack a piece of paper on one side of each board. Stand one board in a flat of soil, the other in a flat of sod. With a sprinkling can, pour "rain" on the ground in front of each stick. Examine the papers, and measure how high soil has been splashed on each stick. What happens when raindrops hit the ground? The sod? What happens to the soil once it is loosened? Where does it go? If sod, leaves, pine needles, or any other mulch covers the soil will the soil be loosened as easily as soil that has not protection? How does this information benefit home owners or farmers?



E. Materials: Hammer, nail, tin can, soil

Procedure: Make many holes in the bottom of a tin can by using a hammer and a nail. Make a little hill of soil in your yard. Make a little road on your hill. Put water in the can and hold it over the hill. Let a little water fall on the soil. What is happening to some of the soil? Can you still see your little road? Observe in your neighborhood the following natural procedure:
Go out after a heavy rain and find places where the soil has been washed downhill. Why doesn't all the soil wash away?

20. **Leading Question:** What effect does running water have on bare soil compared to soil covered with growing plants?

Materials: Two wooden boxes, large piece of sheet plastic, soil, piece of sod, sprinkling can, two large jars or buckets, two short pipes or pieces of hose, water

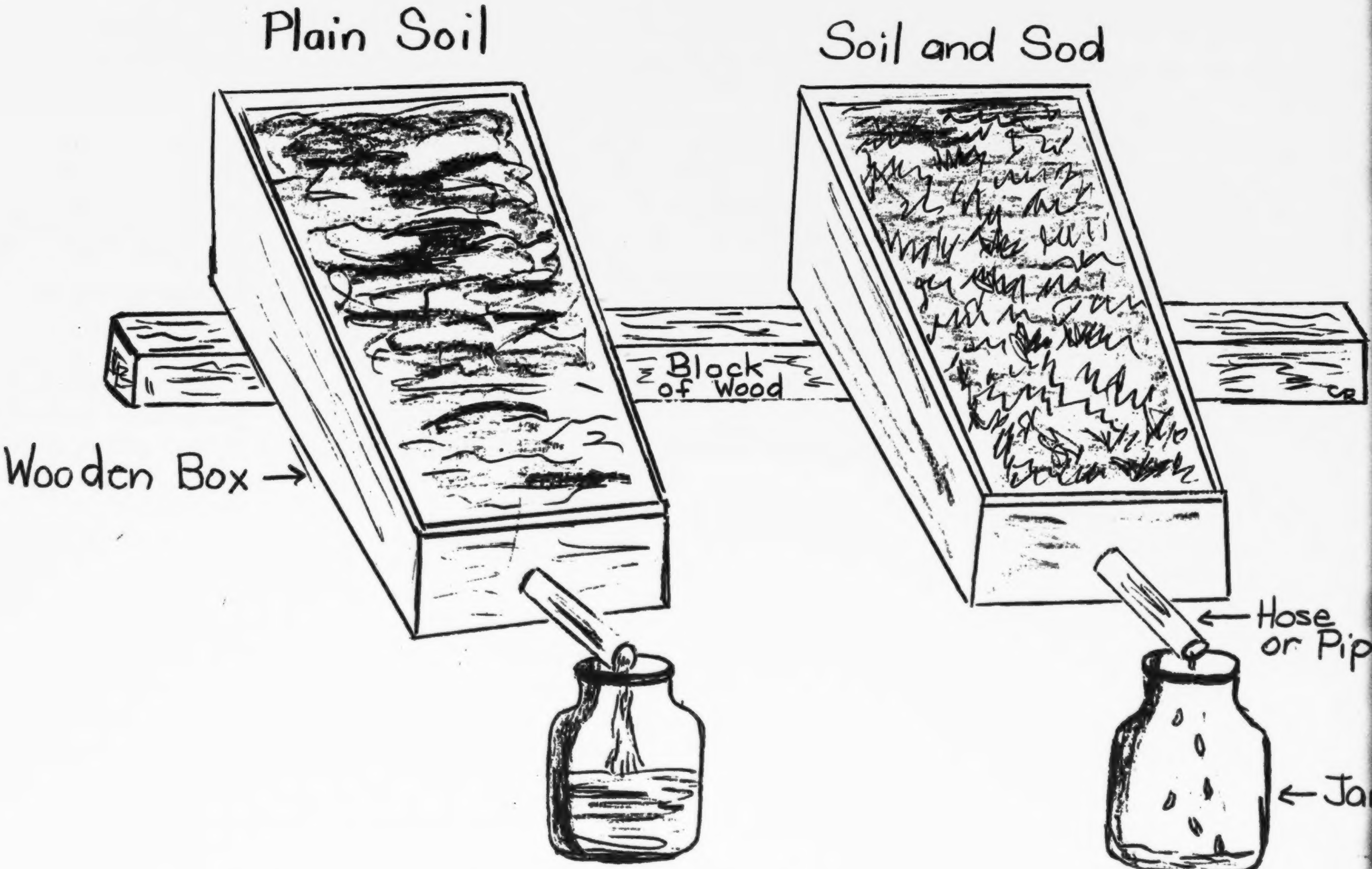
Procedure: Place two wooden boxes side by side on a table. Line the boxes with sheet plastic to prevent water from seeping through. Cut a hole in each box for drainage of water, through a pipe or hose, into two large jars or buckets. Fill one box with soil and the other with soil and sod. Slant the boxes by placing a block of wood under one end of each box. Each day, sprinkle a measured amount of water in each box to be caught again after it has run through the soil. Examine the amounts of water runoff from each box and keep a record. Compare the color of the water from each box. Keep a separate chart for each box. Which box has the largest amount of runoff each time? Why? Which jar has the cleanest water? Why?

BOX 1

Date Watered	Amount of Water Used	Amount of Runoff Water	Amount of Soil Runoff
April 6	1 quart	3/4 quart	Very muddy

BOX II

Date Watered	Amount of Water Used	Amount of Runoff Water	Amount of Soil Runoff


Plain Soil
Soil and Sod
Block of Wood
Wooden Box →
← Hose or Pip
← Ja

21. **Leading Question:** How do plants help form soil?

A. **Materials:** Magnifying glasses

Procedure: On a field trip, try to observe a progression of growth on rocks which leads to formation of soil. Use a magnifying glass.

Note to teacher: There is a cycle of growth of living matter, its dying and decaying to form soil for the growth of another plant. Lichens are small-grayish scales that grow on barren rock. When lichens die, they form a thin layer of soil that allows for the growth of moss. The decayed moss thickens the layer of soil and allows a plant seed to grow. Gradually, therefore, soil grows over barren rock.

The teacher should preview the area to chart the trip so that this gradual growth can be shown. i.e. Find a rock with lichens, then one with a thin layer of soil, to be followed by moss growth, etc.

B. Materials: Film or filmstrip of the growth of lichens, transparencies, and Overhead Projector, screen

Procedure: See a film or filmstrip on the growth of lichens. Make your own transparencies of the growth of lichens on rocks. Make overlay transparencies in order to complete the picture. Each drawing should be drawn on an overlay transparency.

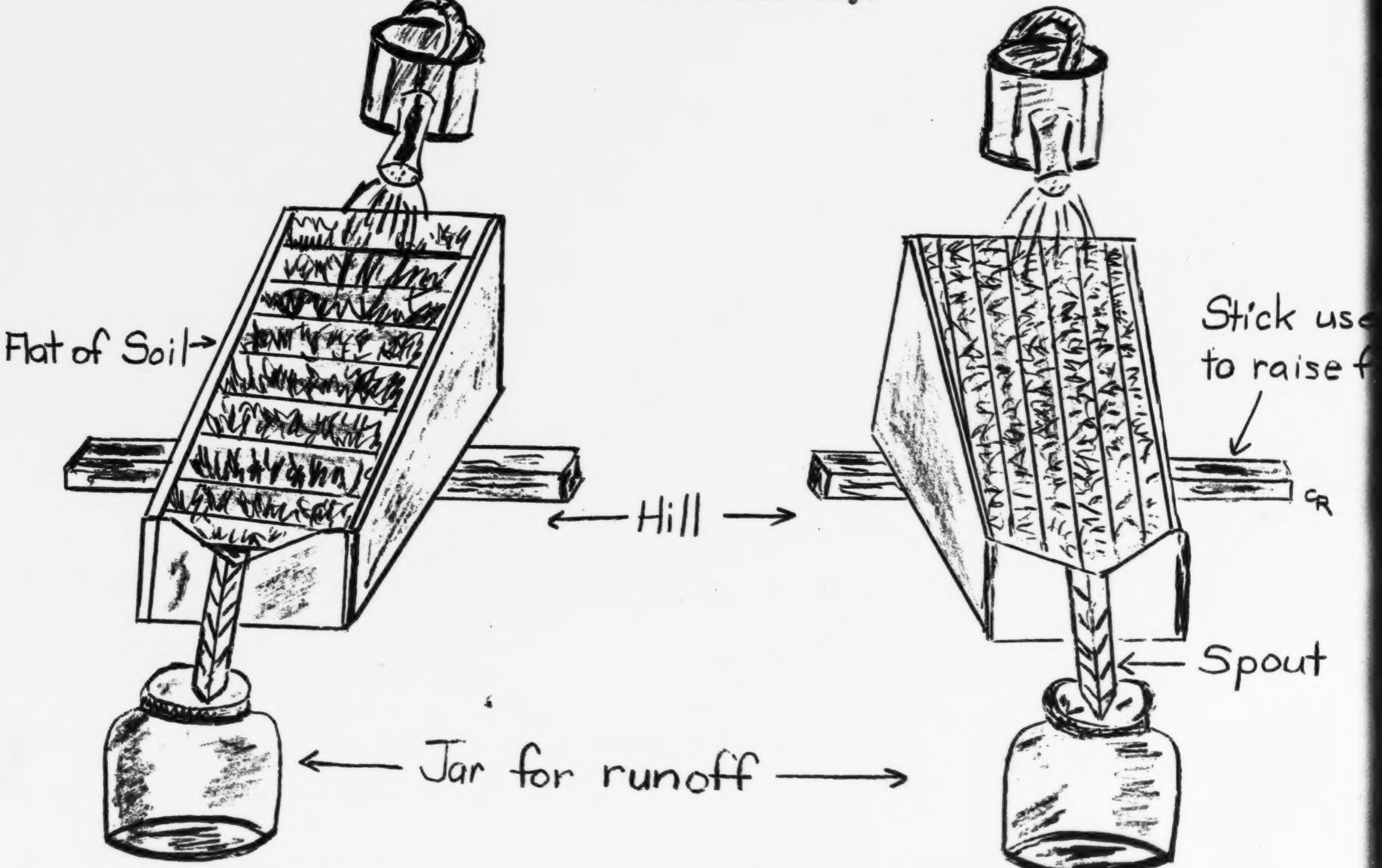
First drawing - Picture of a rock.
Second drawing - Draw some lichens on a rock. (small grayish-black scales) Lichens scar the rocks and then die. When they die they form a thin layer of soil.
Third drawing - Draw green moss growing in the lichen's soil.
Fourth drawing - Green moss dies and leaves more soil.
Fifth drawing - Seeds of other plants land and grow on the rock.
Sixth drawing - These plants die and form more soil for more plants.

22. Leading Question: Why do farmers use "contour" plowing rather than cultivating up and down hills?

Materials: Two flats of soil, tar paper or aluminum foil, two one-gallon jars with wide mouth, sprinkling can, two short sticks, pencil

Procedure: Line two flat boxes with tar paper or aluminum foil to make them waterproof. Partly fill each box with soil and pat it down. Raise one end of each box by placing short sticks under the boxes. In one box make furrows across the slope by pressing across the soil with a pencil. In the other box, make the furrows down the slope.

Make tar paper or aluminum foil spouts to direct the runoff water into the one-gallon jars. With your "rain-maker" sprinkle about the same amount of water into each flat. Compare the runoff in the jars. Why? Which jar contains the most soil? Which method gives the most protection from erosion? Why?



23. Leading Question: How do sediments settle in water to form layers?

A. Materials: Jar with screw top lid, coarse sand or gravel, fine sand, soil, water, siphon tube

Procedure: Fill a jar half full of water. Add some coarse sand or gravel, fine sand, and some soil to the water. Screw the lid on the jar. Shake the contents until they are well mixed and allow to settle. Siphon most of the clear water off and add additional layers until the jar is full. Each time a batch of new material is added, notice which material always settles first and so on. Can you see the different layers of sediment?

As a special assignment, list some sedimentary materials as shown below and have the children decide which sedimentary process is involved and the kind of sedimentary rock that will result from this process.

Note to teacher: Draw, from the children, the information in order to fill in the chart.

TABLE OF HOW COMMON SEDIMENTARY ROCKS ARE FORMED

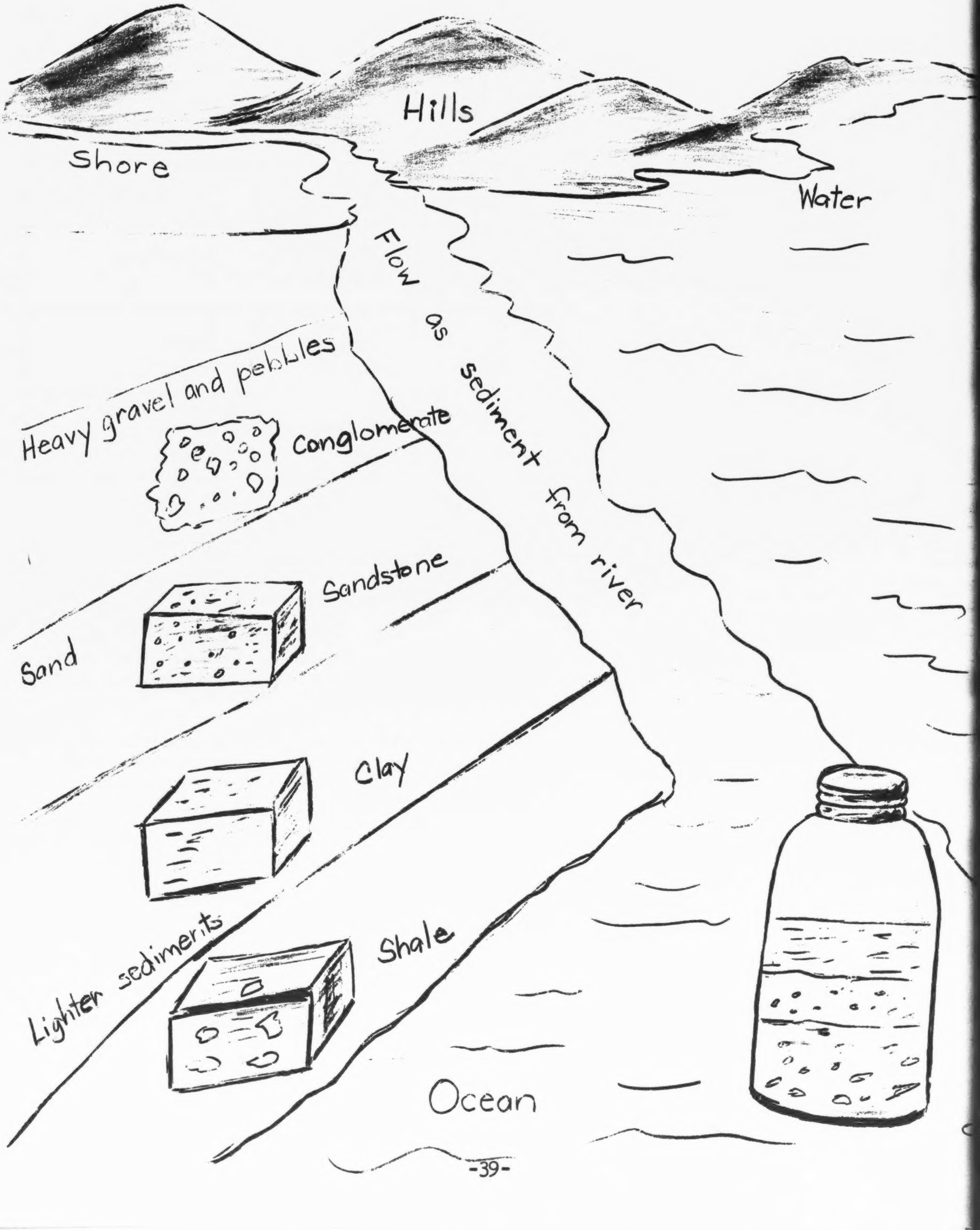
Sediment	Process	Sedimentary Rock
Gravel	Cemented	Conglomerate
Shells	Cemented	Limestone
Sand	Cemented and Pressed	Sandstone
Clay or Mud	Cemented and Pressed	Shale
Twigs and Leaves	Pressed	Coal

24. **Leading Question:** What happens to sediment when it flows quickly? What happens when it slows down?

A. Materials: Garden soil, jar, measuring cup, water

Procedure: Mix a cup of soil with two cups of water in a jar. Shake it. What happens to the soil when the water is moving quickly? Let the jar stand for a while. What do you observe?

When a fast flowing river flows into the sea, which sediments will drop closer to the land? Why? Which sediments will flow farthest into the ocean? Why?


Hills
Shore
Water
Flow as sediment from river
Heavy gravel and pebbles
Conglomerate
Sandstone
Sand
Clay
Lighter sediments
Shale
Ocean

B. Materials: Cupful of each (gravel, sand, garden loam, local subsoil), gallon jug, funnel, water

Procedure: Partly fill a jug with water. Add all the ingredients. Shake the jug thoroughly; allow the soil to settle. Examine the jug the next day. Which material settled to the bottom of the jar? Why? Which material remained on the top? What do you see between the top and the bottom layers? Is the water on top clear or muddy?

25. Leading Question: How are rocks made harder and more compact by pressure?

Materials: Newspaper, piece of cardboard, slice of soft bread, a weight (several books)

Procedure: Spread newspaper on a table. Place a piece of soft bread on the newspaper and cover it with a piece of cardboard. Place a pile of books on top of the cardboard and leave overnight. The next day, remove the books and the cardboard. Take the piece of bread in your hand. Has it changed? Is it thinner than it had been? Does it feel softer or harder? Why? Can you understand how rocks are made harder and more compact by pressure over millions of years?

26. Leading Question: How can man make a sedimentary rock?

Materials: Pebbles, sand, powdered clay, bits of clam shells, bits of oyster shells, plaster of Paris, builder's cement (mortar), water, shoe box, aluminum foil

Procedure: Line a shoe box with aluminum foil. Make one layer of sediment at a time. Allow each layer to settle and harden before beginning the next layer.

First layer: Mix about one part of sand and one part of builder's cement with water. Cover the bottom of the shoe box to a depth of one-half inch.
Second layer: Combine a mixture of clay and plaster of Paris with water, and pour it on top of the first layer and let it harden.
Third layer: Make a mixture of sand, cement, and bits of shells.
Fourth layer: Use pebbles combined with some sand-cement mixture to form this layer.

Continue alternating layers until the shoe box is filled. In a few days when the material is hard, cut away the shoe box and study the sedimentary rock. Make a label to show the contents of each

	layer. What caused the particles to cement together? How long did it take to make this rock? How long does it take nature to make a sedimentary rock of the same size? What might be in the layers of nature's sedimentary rock?
27. Leading Question:	How is sandstone formed?
A. Materials:	Two pieces of sandstone, sand, magnifying glass, stereo-microscope (Central Science Materials Library)
Procedure:	Rub two pieces of sandstone together. Grind them together until you are able to examine the resulting grains of sand through a magnifying glass. Examine some other sand by using the stereo-microscope and compare it with the sand from the sandstone.
B. Materials:	Tin can, sand, cement, water, sandstone
Procedure:	Mix some sand and cement with water. Place the mixture in a shallow tin can until it hardens. Compare the prepared mixture with the natural sandstone. What holds the sand together in both kinds of sandstone?
28. Leading Question:	How can man make shale, limestone and sandstone?
Materials:	Discarded milk cartons, small amount of cement, lime, plaster and sand
A. Procedure:	Mix cement and water in one milk carton to produce a kind of shale. Leave it in the carton until it is dry and then peel off the carton. Label it.
B. Procedure:	Mix lime, plaster, and water in another carton to make limestone. Later, this can be tested with vinegar to see if it bubbles.
C. Procedure:	A synthetic sandstone will result from a mixture of sand, cement, and water. Label each mixture when it is dry.
Note to teacher:	Remind the children that in nature, however, the hardening of sediments into rock takes hundreds of centuries.
29. Leading Question:	How are the skeletal parts of sea animals formed which eventually go into the formation of limestone?
Materials:	Lime tablets, drinking glass, drinking straw, shallow dish, water

Procedure:

Dissolve some lime tablets in a glass of water. Look at the limewater. Is it clear or cloudy? Put a drinking straw into the limewater and blow your breath into it. What happens when the carbon dioxide from your breath enters the water? Is the water clear or cloudy? Keep blowing until the limewater stops getting milkier. Then stop blowing. Let the limewater stand for a while. What do you see in the bottom of the glass? Pour the limewater into a shallow dish. Let the water evaporate for a few days. What remains in the bottom of the dish?

Note to teacher:

The carbon dioxide from your breath came together with the lime in the water, and made limestone. Sea animals build their bones and shells in the same way. All around them is sea water with lime dissolved in it. The animals have carbon dioxide inside themselves. The carbon dioxide and the lime come together inside the animal's body to form their shells bit by bit.

30. Leading Question:

What proof do we have that shells and limestone are the same materials?

Materials:

Knife, limestone and other stones, hydrochloric acid (diluted), vinegar, lime tablets, phenophthalein, jar, water, seashells

A. Procedure:

Use the scratch test to find a soft stone. Scratch with a knife. If you are not sure it is limestone try some other tests to make sure it is not slate, shale or clay.

B. Procedure:

(This is an experiment for teacher demonstration.) Dissolve some pieces of limestone and shells in diluted hydrochloric acid. Examine the "insoluable residue" with a hand lens to see what the rock contains beside calcite.

C. Procedure:

Heat some vinegar or let it stand in the open air for a few days until the water evaporates. Pour the vinegar on some limestone or shells. What happens when the vinegar touches the limestone or the shells?

D. Procedure:

Dissolve lime tablets in some water. Procure some phenophthalein solution from the Central Science Materials Library. Add a few drops to the limewater solution. What happens to the lime solution?

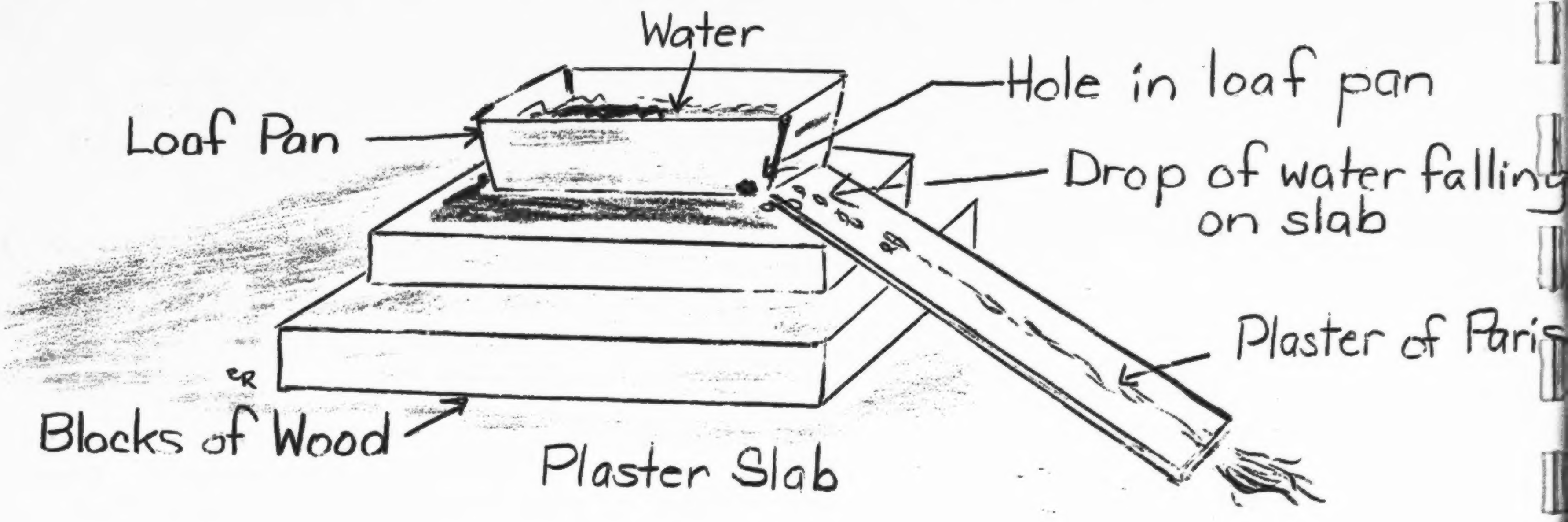
Note to teacher:

(Children should not handle hydrochloric acid.) Bubbles appear on the limestone. Phenophthalein added to limewater turns red. This is the only testing of rock done in third grade. Much of this unit is on sedimentary rock including limestone.

31. **Leading Question:** How can we prove that water can dissolve considerable amounts of some kinds of rock?

Materials: Plaster of Paris, aluminum foil, long shallow pan, blocks of wood, cake loaf pan, needle

Procedure: Line the cover of a shoe box with aluminum foil to make it water tight, or use a long shallow pan. Mix some plaster of Paris with water to make a thick paste. Pour about three-fourths of an inch of this mixture into the box lid. Allow it to harden and then remove the plaster slab. Take the slab outdoors and prop it up about two inches on a small block of wood. Punch a very small hole, with a needle in the bottom of a cake loaf pan. Fill the pan with water to produce a steady drip from the hole. Support the pan of water on some blocks of wood so that the water falls on the raised end of the plaster slab, and trickles down its surface. Keep this trickle flowing for several days. What gradually happens to the surface of the slab? What kind of rock does the slab of plaster represent? What do you see at the end of the slab where the water has run off on the ground? What does this prove? What evidences do we have that prove that limestone is dissolved in this way?



32. **Leading Question:** How are limestone caves eroded?

Materials: Seashells, pieces of limestone, clear vinegar, drinking glass

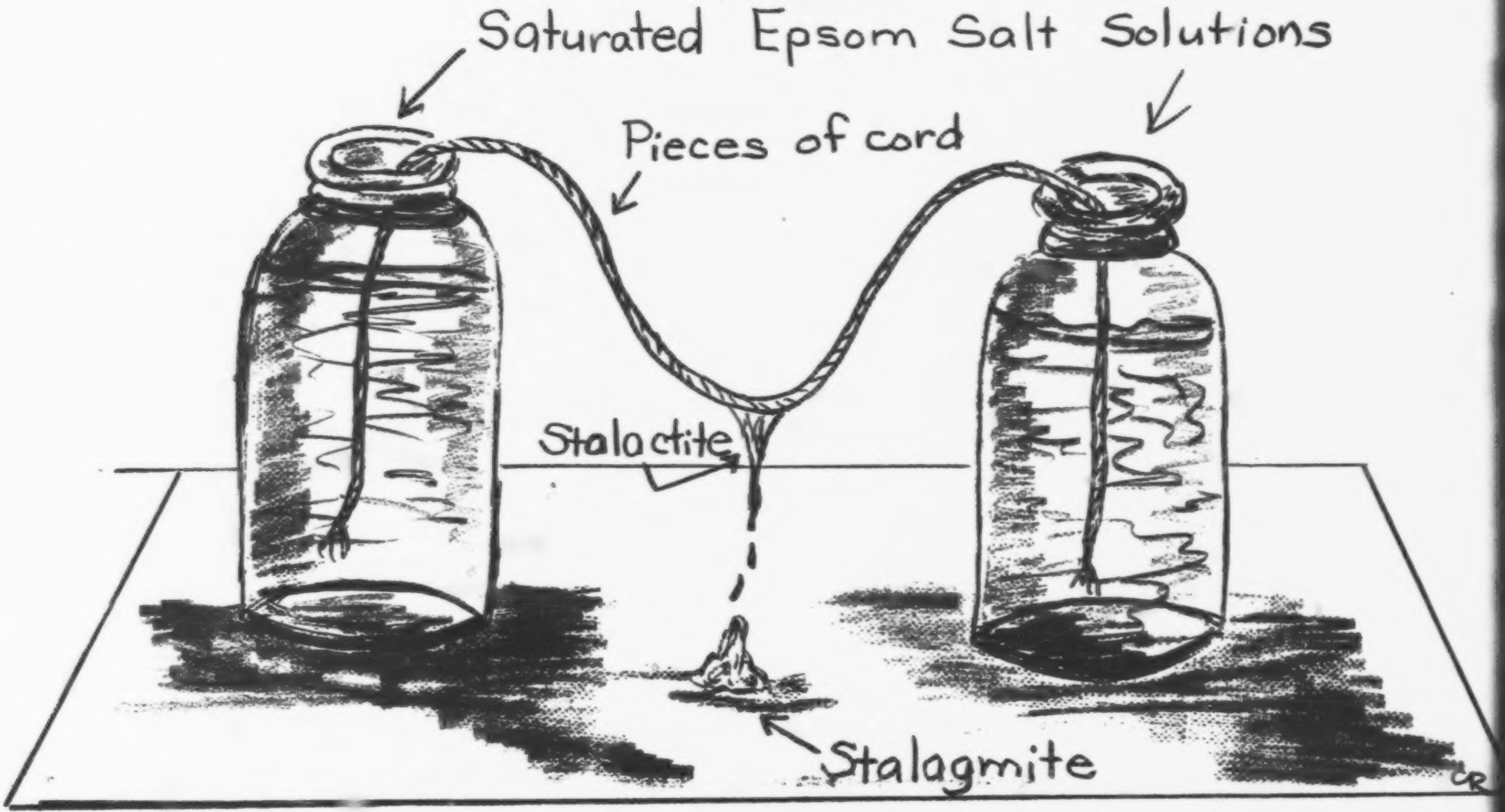
A. Procedure: Break up some seashells and small pieces of limestone. Put the bits of limestone and shell into a glass. Pour some vinegar over them. What do you observe? Leave the shells and limestone in the vinegar for several hours. Pour off the vinegar. Scratch the shells and the limestone with your fingernail. What happens? What do you think happened over a period of thousands and thousands of years as water seeped down through the limestone deposits? Where did the dissolved limestone go?

B. Procedure: Visit Lost Cave or Crystal Cave for firsthand observations.

33. Leading Question: How can we demonstrate the formation of stalactites and stalagmites?

Materials: Two jars, piece of cord, Epsom salt or table salt

Procedure: Discuss your observations of a cave. Examine pictures of caves. The formation of miniature stalactites and stalagmites can be demonstrated by laying a cord between two small jars filled with a saturated solution of Epsom salt to represent the calcium carbonate, dissolved out by ground water. What is happening as the solution soaks into the cord? Do you see what happens as the water drips from the cord? How many things do you see appearing? How can you apply what you observe to the formation of stalactites and stalagmites in caves? From what kind of rock is the cave formed?



34. Leading Question: Does air carry sediments?

A. Materials: White pan, water, filter paper or similar material

Procedure: Place a white pan, half filled with clean water, on an outside window sill. Let the pan stand there for several days. Carefully move the pan back into the room without stirring up the water. Examine the water for evidence of sediment. What do you see? Where do you see it? How did it get there? Pour the water through a piece of filter paper. What do you see on the filter paper after the water is run through?

B. Materials: White facial tissue, soap and water, clean rag, chart

Procedure: Keep a record of the dust that settles on a particular part of a window sill. Wash the sill with soap and water and let it dry. Immediately after it is dry, rub a facial tissue over the spot to show that it is clean. Save, and label the tissue. Test at various intervals of one hour, three hours, six hours, a week. Which tissue gathered up the most dirt? Where did the dirt and dust come from? How did the dirt and dust get to that particular spot? How far do you think dust and dirt can travel in this way? Paste the tissue samples on a chart and label.

35. Leading Question: What effect does heat have on clay?

Materials: Clay from the earth, kiln

A. Procedure: Try to find some clay in the bank along a river or stream. Sift the clay to remove all other materials such as plants, insects, and pebbles. If you cannot find your own clay, request some from the Art Department. Shape the clay into a small piece of pottery or tile and let it dry. Place the dry product in the kiln and bake. Remove your pottery or tile from the kiln and allow it to cool. How does the clay feel after it has been exposed to the heat of the kiln? Do you remember how the clay felt when you shaped your piece of pottery or tile? How did it feel just before you put it in the kiln? How does heat change clay? What effect does the sun have on clay soil?

B. Procedure: Make a survey of your home and list all the things you can find made of clay.

ACTIVITIES TO ASSIGN FOR HOMEWORK OR INDIVIDUAL RESEARCH

36. Leading Question: How does the surface of the earth differ from one place to another?

Materials: Travel folders, geography books, National Geographic Magazine and other magazine pictures, newspaper pictures

A. Procedure: Study pictures of the earth's surface. Travel folders, geography books, National Geographic Magazine and other magazine and newspaper pictures show many of the earth's topographical features. Study these pictures to see how the surfaces differ from one another, layers of different kinds of rocks, how the layers are tipped and twisted, and where the snow and vegetation are.

B. Procedure: Look at pictures of different places on the earth - seashore, mountains, deserts, farm land, etc. Tell what you see in each picture and how the places are different, i.e., rough, smooth, high, rocky, wet, etc. Write short reports and hand in for homework or make reports to the class.

37. Leading Question: How does soil differ from one area to another?

A. Procedure: List local industries depending on earth materials. Use a classified telephone book for reference. Write to the Chamber of Commerce for information.

B. Procedure: Get a bucketful of earth from the garden or a vacant lot. Examine the earth bit by bit on white paper or toweling to see the varied composition. Make separate piles of pebbles, roots, sticks, and the like. Have a collection of plastic pill bottles, or other containers for sowbugs, earthworms, or other animal life of the soil. When the soil is partly dried out, sift it through sieves or wire mesh of increasing fineness. Make separate piles of each screening. Place partly disintegrated plant or debris in separate piles. Try the same process from soil of another area and compare.

38. Leading Question: How can we tell the difference in rocks in our area?

Materials: Rock samples, mineral salt, stereo-microscope

A. Procedure: Make your own rock collection with a half or full dozen samples of the same type of rock. Label and display your own collection in an egg carton or cigar box. Feel the rocks to see how they are alike or different. Scratch them with a nail to see the difference in hardness. Observe the color, shape, size and other characteristics.

B. Procedure: Make a list of things made from earthy materials in or around your home. Some of these might be chalk, clay pots, china, copper, iron, steel, porcelain, glasses, aluminum, slate, etc.

C. Procedure: Examine some mineral salt under stereo-microscope magnification. Rock is made of mineral crystals "packaged" together.

39. Leading Question: How can we see the effects of a stream or rainfall on the land in our area?

A. Procedure: Follow a stream to see:

a. How the stream has changed the earth around it.
b. Load being carried.
c. Swiftness of the stream.
d. Deposits of the stream.

B. Procedure: Observe a local area, after a heavy rainstorm, to determine:

a. Where erosion is taking place.
b. Why it is taking place.
c. Materials that are being carried away.
d. Where materials are being deposited.
e. Effects of deposits.

40. Leading Question: What are the different uses of rocks in our area for building purposes?

A. Procedure: Observe the use of rocks. Many buildings are made of different kinds of rocks. Granite, marble, or sandstone may be used in construction. Observe schools, churches, banks, libraries and other public buildings to see examples of the different kinds of rock. Make a chart with pictures of different buildings and list under each picture the earth materials used in each.

B. Procedure: Make a collection of stones rounded off by water. Arrange the collection according to size, color or weight.

C. Procedure: Make a collection of pictures showing contour plowing on farmland.

Note to teacher: The above may be used as an independent activity.

41. Leading Question: How do dead plants make up some of the soil?

A. Materials: Leaf, pie pan, soil, water

Procedure: Place a leaf in a flat container half filled with mud. Pour additonal mud on top of the leaf until the container is filled. Allow the container to stand uncovered until the mud thoroughly dries and hardens. This may take several days. Carefully pick through the hardened mud to find the imprint of the leaf. Examine the leaf for signs of decay. Do you understand how dead plants eventually make up some of the soil?

B. Materials: Leaves, grass, weeds, roots, hammer, soil, jar

Procedure: Collect some leaves, grass, weeds, and roots. Let them dry out for about a week. Break up the dried plants and pound them into very fine particles until you are not able to recognize them. Put some garden soil into a jar. Mix the dried particles with the soil by shaking thoroughly. Do you understand how plants become part of the soil? Is it easy to see the plants now?

42. **Leading Question:** How does the Bethlehem Steel Company benefit from the uses of rocks and minerals?

Materials: Library books, booklets on steel-making

Procedure: What are the important materials in the making of iron and steel? Allow the children to state their views and then back-up their knowledge by referring to library books on steelmaking.

Note to teacher: Iron ore, limestone, coal (coke) are the main materials in iron and steelmaking.

43. **Leading Question:** What are the mineral needs of a farmer?

Materials: Encyclopedias and other resource books, Agricultural Statistics (an annual publication of the U.S. Department of Agriculture), Economic Almanac, World Almanac

Procedure: Read to find how the farmer is dependent on our mineral resources.

Note to teacher: Allow the child to list possible uses such as steel, fuels for power, limes and fertilizer minerals, and minerals needed for farm structures.

44. **Leading Question:** Which metal is most essential to man in the modern world?

Materials: Encyclopedias, science reference books

Procedure: Divide the class into several groups to discuss the topic "What is the most important metal in the modern world? (iron, copper, aluminum, lead, uranium, etc.)" Let each group get information from encyclopedias and other science source books to back up their statements on the value of the metal. Have a discussion involving a principal spokesman from each group. What final decision do they make? Do all the groups agree?

Note to teacher: It will usually be decided that iron is the most valuable metal because of its use in making steel and the demand for a large number of its products needing strength and durability.

45. Leading Question: How does a geyser perform?

Materials: Coffee percolator, water, hot plate

Procedure: Remove the glass top from a percolator. Heat some water in the percolator on a hot plate. Watch the water boil up through the central tube much as it does in geysers of Yellowstone National Park and other hot springs. Keep the heat low while observing the spurts of boiling water coming up from below.

Note to teacher: A geyser is a hot spring equipped with a natural plumbing system that causes water and steam to be shot up. The essential "plumbing" structure in a geyser is a natural tube extending from the surface down to very hot rock. Inflowing water is heated above the boiling point. The rise of a few steam bubbles throws some water out at the top. The loss of this water reduces the pressure enough so that the superheated water below explodes into steam, blowing out water above the geyser. Then the cycle starts all over again.

DIGGERS TO DIVERS

Petrology

Grade 4

Rocks, Minerals, Soil

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The study of rocks is called petrology.	
The earth's crust is made up of three main types of rock, classified according to their origin: igneous, sedimentary, and metamorphic.	21
Igneous rock is formed when molten material hardens. (The term magma applies to molten rock below the earth's surface. The molten rock which flows from a volcano is called lava.)	21
When molten material cools, crystals are formed.	20
Sedimentary rocks are formed when sediments settle out of water or when rock fragments are pressed together.	21
Metamorphic rocks form from igneous and sedimentary rocks as heat and pressure are applied.	21
Rocks may also be classified according to mineral composition structure (or texture) and color.	22
Some rocks are porous and are capable of holding more water than others.	
A mineral is an inorganic substance usually a solid, composed of one or more elements.	22
Minerals are found naturally in the earth's crust.	
Most rocks are composed of a mixture of minerals, but some are made of only one mineral.	2,30
Moh's hardness scale is a rating of minerals according to their ability to resist scratching.	22,31
Most minerals are crystalline, that is, their atoms or molecules are arranged in a definite pattern.	23,28,29
A crystal is a regularly shaped solid with angles and flat surfaces.	5,14,20,28
Some pure crystals, used in jewelry and industry are very valuable.	

UNDERSTANDINGS TO BE DISCOVERED (Cont'd.)	RELATED ACTIVITIES
Chemical properties are studied for rock identification.	15
Certain minerals can be identified by their physical properties: fluorescence, luster, translucence, cleavage, streak, specific gravity, and tenacity.	25,32
Over millions of years the same minerals are built up into rock and then broken down to form soil particles. This constant changing of the earth's crust is called the rock cycle.	7,8,24
Weathering and erosion affect the physical appearance and the chemical composition of the earth's surface.	33,34,35,36
To hunt for rock specimens, the geologist uses specialized tools and complex instruments.	
Amateur geologists can find and identify rocks with a few basic tools.	21
Soil, a most valuable resource, is composed of particles or rock, sand, silt or clay, and humus.	12,19,27
Climate is the greatest influence on the kind of soil produced in an area, but vegetation, topography, parent material, time, lichens and small plants are also important.	
The mineral content of the soil affects its value for farming.	26
Seepage rate in some soils is more rapid than in others.	13
Mining is the process of taking ore, rock, precious stones or coal from the ground.	
The two main types of mining are surface and underground mining.	
Mineral processing is separating the materials in ore by magnets, flotation, smelting, electricity or other means.	4,6,9,10,32

Petrology

Landforms

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Many forces are at work today changing the surface of the earth.	
Natural history can be studied by examination of rock layers (Stratigraphy).	
Geographers measure the altitude of land in relation to sea level.	1
Various landforms occur where land and ocean meet. Among these are: islands, archipelago, gulf, peninsula, estuary, isthmus, harbor, and delta.	
Moving inland from the ocean these landforms are commonly found: coastal plain, piedmont, fall line, alluvial plain, mountain range, plateau, desert, escarpment, and canyon.	

DIGGERS TO DIVERS

Grade 4

Petrology

Paleontology

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The science of paleontology studies fossils, the remains of organisms that lived millions of years ago.	3
Most fossils are found in rock which hardened from sediments deposited at the bottoms of ancient seas and lakes.	
Many organic remains have been altered or petrified by permineralization, replacement or carbonization.	18
A few dried bodies (mummies) of ancient animals have been found where rapid drying prevented decay.	16
Many fossils are prints (molds or casts) of ancient plants or animals.	3,17
Fossils show evidence of great changes in the climate and landforms of a certain area.	16
The deepest layers of fossil-bearing strata are the oldest and contain the remains of the most primitive life forms.	
Throughout natural history each age has been represented by the dominant flora and fauna which were best adapted to the environment of that period of time.	
The invention of radioactive dating in the early twentieth century aided geologists in determining the absolute ages of rocks.	
Earth's history seems to fall into four great eras, each ending with a violent change in landforms and climate: Cryptozoic, Paleozoic, Mesozoic, and Cenozoic.	11
Some of the oldest known preserved animals have been found at the bottom of the Grand Canyon.	
Rock formations and unusual landforms in the National Parks reveal much concerning natural history.	

DIGGERS TO DIVERS

Grade 4

Petrology

County and State Geology

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The five major physiographic regions of Pennsylvania, aligned in northeast - southwest direction, include plains, plateaus and mountain ridges and valleys.	1
Much of the soil in the state is fertile and good for agriculture.	26
The most common rock in Pennsylvania is very ancient sedimentary rock, although some igneous and metamorphic rocks are found in the southeast portion of the state.	21
Minerals are important in the natural wealth of Pennsylvania and have led to the production of cement, clay, coal, gem stones, lime, natural gas, peat, petroleum, sand and gravel, stone and zinc.	
Rounded and worn pieces of rock foreign to Pennsylvania give evidence that two glaciers covered the northeastern and northwestern sections of the state.	
Glaciation in Pennsylvania has altered the scenery, provided rich soil and sand and gravel deposits, and affected the water supply and river systems.	
Evidences in local rocks prove that the land of Northampton County has undergone several periods of uplifting and wearing down during the last billion years.	
The iron ore, slate and limestone deposits led to settlement and industrial development in Northampton County.	
The limestone deposits in the state have produced many sinkholes and caves.	

DIGGERS TO DIVERS

Grade 4

Petrology

ACTIVITIES

1. **Leading Question:** What does Pennsylvania look like when you're high above it in a jet?

Materials: Aero (or Nystrom) Relief Map of Pennsylvania.

Procedure: Place the Aero Relief Map on the floor so that groups of children can stand and observe the surface features, pretending they are high above the land in some aircraft. Have pupils observe and feel the varied landform representations. They will probably note the five physical regions: Lake Erie Plain, Allegheny Plateau, Ridge and Valley Region, Piedmont Plateau, Coastal Plain. Encourage them to locate the landform in which they live, and trace local rivers from source to mouth.

Note to teacher: The scale used for altitude is not in proportion to the scale of surface miles on the map. Guide children to discover that relief is exaggerated.

2. **Leading Question:** Where can we find gold?

Materials: Collecting jar, stainless steel spoon, hand lens, eight-inch layer cake pan.

Procedure: Pupils who are going to the beach or to mountain streams can look for dark (black) patches in the sand. Have them bring a pail of this sand to class, so that everyone can share in the prospecting. Pour about a half-inch thickness of sand in a cake pan, cover it with an inch of water and gently shake the pan back and forth. The heavier black sand will sink and the light sand can be spooned off. Examine the black sand for tiny flakes of yellow metallic stuff - it may be gold! The remaining grains of black sand may be any of 40 or so minerals. Shiny grains may be garnets or zircons.

3. **Leading Question:** How are fossils formed?

Materials: Milk carton, plaster of Paris, water, small shell, vaseline.

Procedure: Find a small shell with pronounced ridges that will fit into the bottom third of a milk carton. Cover the shell with vaseline and place it in the carton with the ridged side up.

Mix some plaster of Paris, keeping it about the consistency of soft ice cream. Pour the mixture into the carton. Be sure the shell is covered. After two days, peel away the carton and loosen the shell from the mold. Does the imprint of the shell show on the plaster of Paris? How is this like a fossil? Do you think fossils are accurate indications of the appearance of living things? To understand how a cast of the original shell is made, coat the impression with vaseline and fill the cavity with plaster of Paris. After it begins to harden, remove the cast from the mold.

Note to teacher: For comparison with actual fossils, have these materials from the school science room on hand, if they are available: Record of Life in Rock Fossil Collection (Specimens, Chart, Text), What is a Fossil?, Fossils for Beginning Geologists, Plants of the Past.

4. **Leading Question:** How can soluble and insoluble materials be separated?

Materials: Sand, salt, water, jar

Procedure: Mix together a spoonful of sand and a spoonful of salt. Put this mixture in water and shake well. Allow this to set for a few minutes, then pour off the water. What is left in the jar? What happened to the salt? What happened to the sand? Which material is soluble?

5. **Leading Question:** How can we make a crystal?

Materials: Copper sulfate, water, cloth, dish, jar

Procedure: Place some copper sulfate in water. Continue adding the compound until solution is saturated. Filter the solution through a clean cloth. Place some of the solution on a dish and allow it to evaporate. As water evaporates, small crystals will be formed. Place one crystal into a jar containing more saturated copper sulfate solution. Watch the crystal grow. Add more solution if desired. A large crystal can be grown. Examine it carefully.

6. **Leading Question:** How can a mineral be removed from its ore?

Materials: Old pencils, sand, water, test tube, detergent

Procedure: Remove the "lead" from some old pencils and grind it up as much as possible. Mix this powder with some sand and put it in a test tube. Add some water and shake well. Allow the test tube to stand for a few minutes. What happens to the ground-up "lead" (graphite)? Where does the sand go? (It is important to remember that the process of flotation is based on the fact that some materials become "wetted" in water, thus they get heavier and sink. Graphite is a mineral not wetted by water.) What happens if you add some detergent to the mixture? How does the principle of flotation help your mother do the wash?

7. Leading Question: Why are some rocks round?

Materials: Flat sedimentary rock, hammer, jar, water, plastic or paper bags

Procedure: Place a piece of sedimentary rock in a plastic bag and break it into small pieces with the hammer. Place some of the pieces in a jar and add water to fill the jar about three-fourths full. Cover and let everyone shake the jar many times. Remove the pieces of rock and compare them with freshly broken pieces of the rock. What difference is noted? Do the rocks that were in the jar look like rocks from a river bed? Why?

Allow the water in the jar to settle. What do you find in the bottom of the jar? Pour off the water and examine this sediment. Can this experiment be done with other kinds of rock (igneous, metamorphic)? Why is sedimentary rock recommended?

8. Leading Question: How are new rocks formed?

Materials: Sand, gravel, patching plaster, water, milk carton

Procedure: Patching plaster can be used with sand and gravel to cement these rock building materials. Mix one-half cup of each of these with a pint of water. Cut off the top of a milk carton and punch some pinholes in the bottom and sides of it. Pour the rock mixture into the carton and allow to set for a day. Can you tell why the holes were punched in the carton? Repeat the procedure daily until the carton is filled. As soon as the mixture dries, peel off the carton. The layers will be similar to sedimentary rock. Can you think of places on the earth where sediments are being dropped and sedimentary rocks are forming?

9. Leading Question: How are metals removed from ore?

Materials: 1/8 teaspoon copper oxide, 1/8 teaspoon powdered charcoal, test tube, test tube clamp, alcohol lamp

Procedure: Mix together the copper oxide and charcoal. Place the mixture in the test tube. Heat it for several minutes over the alcohol lamp, tilting the test tube away from any persons. Remove the tube from the flame and look inside the tube just above the materials heated. What has formed in the tube? Why was the charcoal used? What minerals are removed from ores by the smelting process?

10. Leading Question: How is coke obtained?

Materials: Bituminous coal, test tube, test tube clamp, gas burner

Procedure: Fill the test tube half full with small pieces of bituminous coal. Hold the coal over the flame, being careful to slant the test tube away from people. Continue heating until no more smoke (gas) is given off. Observe the brown tar which collects on the sides of the test tube. Coal tar has many uses. Find out about some of them. The black material at the bottom of the test tube is coke (carbon).

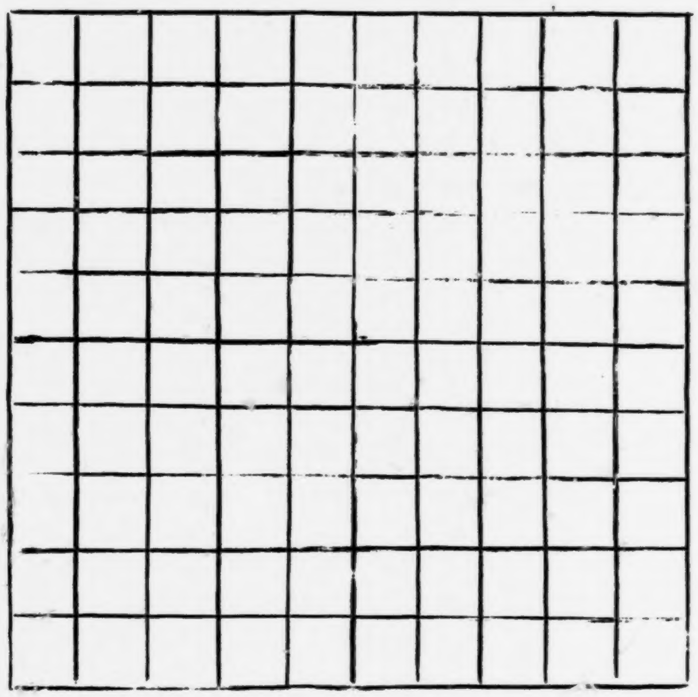
Note to teacher: Perform experiment in well ventilated room.

11. Leading Question: How long is a "long time"?

Materials: Chart or blackboard diagram of large square divided into 100 small squares, individual copies of chart for pupils

Procedure: Let the pupils try to imagine that each small square on the diagram represents 50 million years. All the 100 squares together would stand for five billion years, the approximate age of the earth. Shade in the small squares to show how long man and modern life have been on the earth. (Scientists estimate the present era goes back about 55 million years). Use a different color to indicate the amount of time it took the Colorado River to gouge the Grand Canyon to its present depth (approximately 10 million years).

Do you think you need to shade in much of a square to show your age? Is it a long time until Christmas? Would you say that dinosaurs lived on the earth for a "long time"? Is it scientifically accurate to use the words "long" and "short" in describing the passage of time?



12. Leading Question: **What are the ingredients of a mud pie?**

Materials: Fertile soil, water, quart jar, lid, hand lens, small ladle or bent spoon

Procedure: Place a cup of fertile soil in a quart jar. Add two cups of water, cover and shake vigorously. Set the jar on a table, so that the contents may settle. Remove and identify any material floating on the water. Observe what happens as the sediments sink to the bottom. Is there a difference in the layers of sediment? Use the ladle to remove the sediments by layer from the bottom of the jar. After the materials are dry, study with the hand lens. What materials can you identify? Look for: stringy or spongy humus, fine-grained, dull clay grains, small shining silt particles, large and glassy looking grains of sand, living things.

13. Leading Question: What kind of soil holds the most water?

Materials: A cupful each of peat moss, sand, gravel, and topsoil, four glass funnels or lamp chimneys (of equal size), absorbent cotton, water, measuring cup, four glasses

Procedure: Stuff some cotton in the bottom of each funnel. Put a sample of one kind of soil in each. Place each funnel on top of a glass. Pour a cup of water into each funnel. After a few minutes, measure and chart the amount of water which seeped through each kind of soil. Which soil held the most water? Why? Try this experiment with other kinds of soil. Which kind of soil holds water the longest?

14. Leading Question: What is the shape of crystals?

Materials: Quartz, salt, sulfur, tripod, wire gauze, porcelain dish, gas burner, stereomicroscope, teaspoon

Procedure: Place a teaspoonful of powdered sulfur in a porcelain dish. Heat the sulfur slowly until it melts (looks golden). Let the molten sulfur cool at room temperature. Notice the long needle-shaped crystals that form on the surface. Examine the crystals under the stereomicroscope. Compare and contrast sulfur crystals with the crystals of salt and quartz.

15. Leading Question: How can chemicals help us identify rocks?

Materials: A variety of rocks, including limestone and marble, diluted hydrochloric acid

Procedure: Apply a drop of diluted hydrochloric acid to each rock. Does the material between the grains fizz or bubble? Bubbling indicates the presence of calcium carbonate as the cementing agent. Limestone and marble will respond very well to this test because they are composed mainly of calcium carbonate. After observation, rinse and dry the rock samples.

Note to teacher: This experiment should be performed by the teacher or under close supervision by the teacher.

16. **Leading Question:** How are fossils formed?

Materials: Box, fine clean sand, fresh flowers

Procedure: Cover the bottom of a box with a layer of sand several inches in depth. Arrange some colorful flowers on the sand, then sprinkle on more sand. Several inches of sand should cover the flowers, and they should be allowed to dry for three weeks. Check after this time to see if they are still fresh-looking. What has happened to them while they were buried? What fossils have been found that were covered by wind-blown sand or volcanic ash?

17. **Leading Question:** How can we recover fossils from yesteryear?

Materials: Wrapping paper, vaseline, candle, matches, leaf, newspaper, white paper, forceps

Procedure: The process of carbonization can be visualized quite simply although the concept of the distillation of volatile material and residue of carbon may be somewhat difficult for pupils to grasp.

Lightly coat a piece of wrapping paper with vaseline. Hold the greased side of the paper close enough to a lighted candle so that it can be coated with carbon. (Be careful that it does not ignite). Place the paper, black side up, on a flat surface and drop a leaf face down on it. Cover leaf with a pad of newspaper and press it by hand. Remove the covering and pick up the leaf with forceps. Place carefully on a piece of white paper. Again cover with newspaper and apply pressure. Carefully remove the newspaper and the leaf. How closely does the print resemble the leaf? Remember that this is an artificial coating of carbon. How is this different from what happens in nature?

Note to teacher: Set up safety precautions before performing experiment.

18. **Leading Question:** What changes occur in animals' bodies as they become fossils?

Materials: Cellulose sponge, paraffin

Procedure: The process of permineralization can be demonstrated by using a cellulose sponge to represent the body of an ancient animal. Melt some paraffin and dip the sponge into it. The specimen then is more resistant to chemical and physical deterioration.

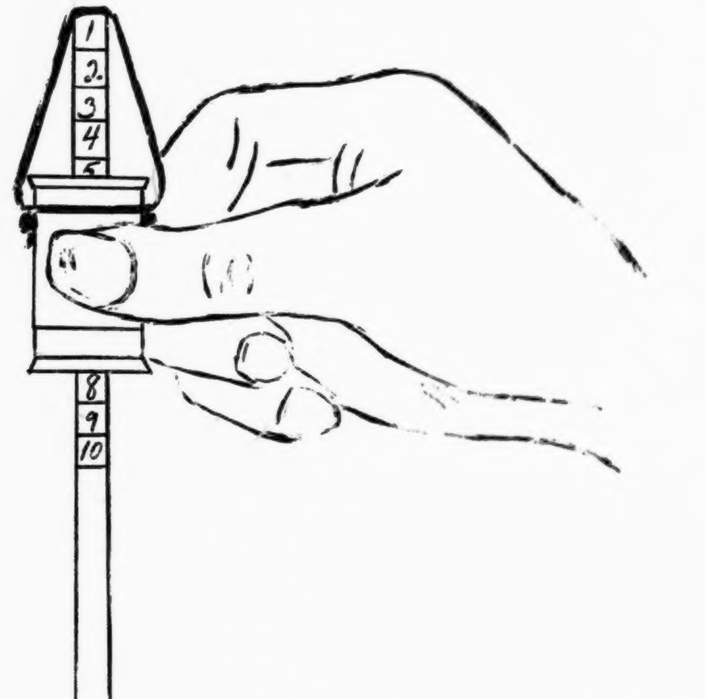
19. **Leading Question:** How hard is the soil?

Materials: Two thumbtacks, wide rubber band ($\frac{1}{2}$"), empty thread spool, 9 inch dowel stick (narrow enough to slide through spool)

Procedure: A simple instrument can be made to compare the hardness of soils around the school and neighborhood.

Sharpen one end of the dowel with a pencil sharpener. Begin at the opposite end to mark off the stick in half-inch units. Number the markings from one to ten. Fasten the rubber band to the top of the spool with tacks. Slip the dowel into the spool catching the rubber band on the unsharpened end. Place a dark line on the dowel stick one-half inch above point. This will be the mark that depth stick must be inserted into soil. Pulling down on the spool, force the point of the dowel into various kinds of soil. When the stick is in as far as the mark, read the number at the top edge of the spool. This number will tell the soil compaction for that location. Try at various places on the playground where grass is growing, at tree roots, areas where children play. Which soil is most compacted? How does this affect growing plants?

SOIL COMPACTION GAUGE



20. Leading Question: How do crystals form?

Materials: Microscope, tripod magnifier, beaker, slide, stirring spoon, hypo, aluminum potassium sulfate, borax, table salt

A. Procedure: The evaporation and cooling of dissolved minerals makes an interesting show in crystallization. Obtain a glass beaker of water, add salt, stirring constantly to help it to dissolve. Continue to do this until no more salt will go into the solution. Obtain a clean slide and place a drop of the solution on the slide. Do not have the drop too thick; spread it out and allow it to dry. Watch closely as some of the salt leaves the solution to form crystals.

Place the slide under the 10X magnification. Watch it as it dries. Look at the edges of the drop. What action is taking place? Where does the action begin? Why?

B. Procedure: Place some warm water in a glass beaker. Add some of the hypo to the water, stirring to help it dissolve. When the solution is saturated, pour a small amount of it into a watch glass and allow the water to evaporate. Again observe under the microscope. Are the crystals the same size and shape as the crystals from table salt?

C. Procedure: Repeat the procedure using aluminum potassium sulfate. How are these crystals different? Try the experiment again using borax (sodium borate). In what ways are all the crystals alike? How are they different? Make drawings of the various types of crystals.

Note to teacher: Contact Central Science Materials Library for chemicals and detailed instructions in reference book, Crystals and Crystal Growing.

21. Leading Question: How can we identify rocks?

Materials: The Story of Rocks - Eaton Scientific Corp; (available in Science Room), assorted sampling of rocks brought by children

Procedure: Ellicit meaning of arrangement of samples in the story of rocks. Have children discover the relationship between minerals and rocks and among the various kinds of rocks. Compare children's rocks with those in display. How many can they identify?

22. Leading Question: How can we identify minerals?

Materials: Samples of minerals to be identified, white porcelain streak plates (or unglazed bathroom tile) Find-a-Mineral Kit - Central Science Materials Library

Procedure: The streak test enables identification of minerals, for each mineral will always show one particular color. Rub a piece of mineral against a white, unglazed tile. Is the color of the streak the same as the color seen when looking at the mineral itself?

Note to teacher: Several schools have streak plates. The Central Science Material Library will provide them for schools which have none.

23. Leading Question: Do molten materials always form crystals when they are cooled?

Materials: Sugar or syrup, beaker, ice water, heat source

Procedure: Heat some sugar syrup to represent molten material of the earth. Pour the hot syrup into a beaker of ice water. Examine what is formed. Does the sugar form crystals? Compare it with obsidian, an igneous rock which is formed when lava cools very quickly. Repeat the experiment, allowing the sugar to cool more slowly. Is there a relationship between length of time for cooling and crystal formation?

24. Leading Question: How does water change rock?

Materials: Sedimentary rock, water, trip balance scale, paper bag

Procedure: Weigh a piece of porous, sedimentary rock. Soak the rock in water overnight. Weigh the rock again. Has the weight changed? Why? Place the soaked rock in a paper bag and put it in a freezer or refrigerator freezing compartment. Are there any changes after the water is frozen? After thawing, examine closely for any changes in the rock.

25. Leading Question: Can rocks float?

Materials: Various kinds of rock including pumice, jars, water

Procedure: Invite the pupils to try to float some of the rocks. When someone finds that the pumice floats, encourage close examination of the physical characteristics of the rock.

26. **Leading Question:** Which soil is best for growing plants?

Materials: Soil samplings, La Motte Soil Test Kit

Procedure: Determine if the soil used by the children in growing plants outside contains the right amount of mineral content for plant growth. Children should not assume that black soil is necessarily good soil unless some tests are run on mineral content. The La Motte Soil Test Kit contains the chemicals needed and the color chart for interpretation. Encourage the children to use it every time they plant seeds and bulbs. Plant food may then be added to counteract the deficiency.

27. **Leading Question:** What materials are found in the mantle?

Materials: Coarse soil, filter paper, slide, funnel, shallow pan, graduated cylinder, microscope

Procedure: Place a handful of very coarse soil in a shallow pan. Pour water over the soil to separate particles. Prepare a filter apparatus by folding the filter paper in half, then in half again. Open the paper so that three leaves rest on one side of the funnel and one leaf rests on the other side. Pour the liquid carefully, so that none spills over the top. Use a graduated cylinder to catch 10 ml of the filtered liquid. Throw away the rest of the liquid, but save the soil in the pan. Spread the soil materials out along the bottom of the pan. Feel and examine the particles of silt. Examine some of the larger particles under low-poker objective of the microscope. Shake the filtered water and examine a few drops under the microscope. Did any particles squeeze through the pores in the filter paper? How small are the particles within soil?

28. **Leading Question:** What does a mineral crystal look like?

Materials: Sand, crumbled soil, salt, sugar, microprojector slides, clear nail polish

Procedure: Spread a thin, even layer of clear nail polish on a clean microscope slide. Sprinkle salt lightly over the slide so that some grains are trapped by the polish. Repeat this process using sugar, sand and crumbled soil. Examine each slide under the low-power objective of the microprojector. Draw a picture of the kind of particle typical of each slide. Do any particles on one slide differ much from the typical one? How do salt particles compare with sugar particles? Are the surfaces of the salt particles smooth or rough? Describe a crystal. Are there any crystalline minerals in the soil?

29. **Leading Question:** How can we identify minerals in compounds?

Materials: Various minerals, copper sulfate crystals, magnesium sulfate (Epsom salt), test tube clamps, Bunsen burner

Procedure: Hold a copper sulfate crystal in a clamp and pass it through a Bunsen burner flame. What happens? Clean the clamp and repeat with magnesium sulfate. How can you detect the presence of copper in a compound? Try the flame test on other minerals. Characteristic flame colors are green from copper, violet from potassium, red from lithium or strontium.

30. **Leading Question:** What differences can you observe among mineral groups?

Materials: Granite, rock containing various minerals, sand, hand lens, stereomicroscope

Procedure: Have each child bring in a rock from his own backyard or neighborhood and examine it very carefully. What color is most noticeable? Are specks of other colors embedded in the rock? Are there bits and pieces that glisten in the light? Is the rock smooth or rough? Do any further differences within the rock become apparent?

Break off a few bits of the rock and examine them under the stereomicroscope. Notice the differences between minerals within a rock. Change the focus with the fine adjustment wheel. What differences are found through the various levels of the piece of rock? Examine granite and sand in the same way. Are they similar in any way?

31. Leading Question: How can we identify minerals?

Materials: Any ten minerals, Find-a-Mineral Kit - (Central Science Materials Library)

Procedure: Select ten minerals from the class collection. Describe each by color and for size to differentiate between them. Label them in some manner for identification in this and other experiments. By scratching one mineral specimen with another, find the mineral from the group that will scratch all the others but cannot be scratched itself. Put this one at the head of a list on a chart. (Further observations may be recorded on this chart through related activities.) Now determine the mineral which will scratch the remaining ones. Repeat the process until all ten are in order, so that, the last one will be scratched by all the others. Does the fact that a mineral can scratch some minerals and not others tell us about its hardness? Does the scratch test assure us of the identification of a mineral?

Note to teacher: Refer to Moh's Hardness Scale in the appendix.

32. Leading Question: How can we determine the hardness of minerals?

Materials: White porcelain streak plate, ten minerals (refer to activity 31), several lightly colored minerals, Find-a-Mineral Kit - (Central Science Materials Library)

Procedure: Rub a piece of mineral across a white porcelain streak plate. Examine to see if the mark on the porcelain has any color. If so, does the color of the mineral seem to have any connection with the color of the streak? Repeat using the lightly colored minerals. Do they leave streak marks? Are the marks similar or different? Perform this streak test on the ten minerals which were charted according to hardness in activity 31. List the streak's color, if any, as a property for identification.

Note to teacher: Refer to the appendix for streak marks of common minerals.

33. Leading Question: How does the weather affect rocks?

Materials: Rock specimens, weathered granite, weathered basalt, sandstone, cloth, hammer

A. Procedure: Examine a piece of rock found on the surface of the ground. Can any evidence be seen of

	weathering? Wrap the specimen in a cloth and hit it with a hammer to break it apart. Is the inside of the rock any different from the outside? How could the weather have changed the rock? (Chemical action may have caused some disintegration.)
B. Procedure:	Examine samples of weathered granite and weathered basalt. Are there some flakes on the surface that easily peel off? Large masses of exfoliated masses of granite can be seen in the National Parks of the West.
C. Procedure:	Soak a piece of sandstone in water for 10 minutes, then place it in the freezer. When it has frozen, soak it again in water. Repeat the process several times. What changes take place in the rock? What does this illustrate about the effects of weather on rocks?
34. Leading Question:	How does the weather change rocks chemically?
Materials:	Limestone, marble chips, sandstone, vinegar, diluted hydrochloric acid, pipette
Procedure:	Use the pipette to put a few drops of vinegar on the piece of limestone. Repeat with marble and sandstone. Is there a bubbly reaction with any of the rocks? Use the diluted hydrochloric acid to watch for reaction of the rocks. The reaction gives evidence of the presence of calcite in the rock. Place some chips of limestone in test tube of diluted hydrochloric acid. Also do this with some small pieces of marble and sandstone. Let the rocks soak for a week. Observe any changes taking place.
35. Leading Question:	How does running water change rocks?
Materials:	Marble chips, diluted hydrochloric acid, rubber band, nylon stocking, microscope, slide, milk container, two jars, three flat bowls
Procedure:	Remove the top and bottom of a milk container. Make a bottom for the carton by fastening on

a piece of nylon stocking with a rubber band. Place a layer of marble chips in the carton. While holding the carton over a jar, slowly pour water into the carton. Identify nearby streams where the water is filtering down (percolating) through the rocks in the stream bed.

Pour the water into several flat bowls, and allow to evaporate. Is there anything left in the bowls? Check for a reaction with diluted hydrochloric acid. Observe the material through a microscope. What is probably happening to a stream bed? How would the speed at which the stream flows affect the rate at which the rocks dissolve?

36. Leading Question: What happens to the soil during a heavy rainstorm?

Materials: Rain water from the ground, soil, cookie sheet, two jars, basin

Procedure: Try to obtain running water during a rainstorm. Allow the water to stand in a jar. How does the water look when it is put in the jar? After a few hours?

If the weather does not co-operate, cover a cookie sheet with an inch of soil. Slant the cookie sheet and pour water from the top of the slope, so that a valley is cut in the soil. Catch the water as it runs off. Observe the water after it is collected and after it has been standing for a few hours. How does erosion change the earth's surface?

DIGGERS TO DIVERS

Oceanography — **Grade 5**

Exploring the Oceans

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The water filling the great basins surrounding the continents is the world ocean.	1,3
Geographers have divided the world ocean into five major oceans.	1
Some parts of the world ocean are divided by points of land forming seas, gulfs, bays, sounds, inlets, and straits.	2
Oceanography is the study of the oceans which encompasses all sciences.	
Man has always been interested in the ocean, but modern technology has only recently allowed scientists to explore and study the depths of the ocean.	4,33,36
There are many methods of modern oceanographic research.	14,30,33,36,53
Scientists use many different types of equipment for measurements, sampling, and undersurface observation.	14,30,33,36
The earth's crust is thinnest at the bottom of the ocean.	38
Water pressure increases with depth.	7,25
Nautical measurement is used in oceanographic exploration and research.	47
Many problems face the underwater explorer.	8,11,29
The study of the ocean has only begun.	

DIGGERS TO DIVERS

Oceanography — Grade 5

Geological Oceanography

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Oceans are several billion years old.	48,49
There are different theories concerning the origins of the ocean.	48,49
There are three main divisions of the ocean: continental shelves, continental slopes, and deep-sea basins.	27,28,37
Ocean islands are formed in different ways.	45
The sediment which covers the ocean bottom comes from a variety of sources.	12,15
Sediment is formed in many layers.	15,24
Sedimentary rocks form continental shelves.	37
Canyons, as deep as those on land, extend into the shelves.	27,48
The crust of the earth under the ocean is composed mainly of different types of basalt.	38

DIGGERS TO DIVERS

Oceanography **Grade 5**

Physical Oceanography

UNDERSTANDINGS TO BE DISCOVERED	**RELATED ACTIVITIES**
Ocean currents are traced and studied by various methods.	42
Ocean currents are caused by convection.	6
Many different currents travel the world ocean.	42
Currents change the ocean's environment.	42
Ocean temperatures vary and affect sea life and man.	41
The earth's rotation affects tides.	31
The moon affects tides differently at different times of the year.	31,43
Waves are caused by the transfer of the energy of the wind to the surface of the water.	18
Waves are not alike but have different parts and sizes.	19
Tidal waves are caused by underwater earthquakes.	50
Currents, waves, and tides affect man's activities and his environment.	32,42,43

DIGGERS TO DIVERS

Oceanography Grade 5

Chemical Oceanography

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
All oceans are a part of the world ocean.	1
Sodium cloride (salt) is the most abundant element in sea water.	23
Many different kinds of elements are dissolved in sea water, and the amount of them determines its density.	5,13,23,40
The density of elements cause a response from sea life.	41
There are many ways minerals accumulate in the ocean.	12,21,26

DIGGERS TO DIVERS

Oceanography

Grade 5

Biological Oceanography

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The number of plants and animals found on land is small in comparison with the number in the ocean.	52
The ocean contains not only large animals, but also microscopic organisms.	16,20,34,35,52
There is a balance of life in the ocean.	17
Food production is dependent on the sun.	17
Plankton is the ultimate source of sea life.	16
Seaweed is an algae closely related to plankton.	44
Animals and plants vary in the ocean according to depth, density of minerals, and availability of food.	20,29,41,52

DIGGERS TO DIVERS

Oceanography

Grade 5

Uses of the Ocean

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
The fishing industry is a major economic factor of nations.	22
Animals provide man with clothing, oil, perfume, fertilizer and many other products.	22
The continental shelf is of economic importance for oil, minerals, and chemicals.	23
The ocean is a potential source of drinking water for man.	9,10
The ocean is a potential source of energy.	51
Minerals are found on the floor of the ocean in the form of nodules.	21,22,23,24,26
The ocean is used for communication and transportation.	22,43
Oyster farming is a well-developed industry.	54
The ocean is used by man as a sewer.	46
Man's methods of farming the ocean are primitive in comparison to farming on land.	54
The ocean presents many great possibilities for the future.	39,46,51,54

Oceanography Grade 5

ACTIVITIES

1. Leading Question: **Are all bodies of water part of the world ocean?**

   Materials: Individual blank maps of the world, individual atlases, research books, maps of the world on the wall. Suggest use of hydrographic relief globe (Central Science Materials Library)

   Procedure: Guide the children to discover that inland bodies of water are not part of the ocean and develop the idea that oceans surround and separate continents. Stress the understanding that all oceans are connected and collectively may be referred to as the "world ocean". Ask them how many oceans they can locate on their maps. Locate neighboring continents, major seaports, and islands. Using the maps, ask them what oceans they might swim in. What ocean might the Japanese swim in?

   Color the maps. These might be included in a notebook.

2. Leading Question: **Make a chart and discuss, define, and locate the following: sea, gulf, bay, sound, inlet, strait.**

   Materials: Ditto of following chart for each child, individual atlas, geographical terms, wall map, research material

   Procedure:

Terms	Sea	Gulf	Bay	Sound	Inlet	Strait
Definition						
List of Names found on Map						
Picture						

Through the use of reference books and maps, develop a definition for each term. Discuss and compare. Go on a treasure hunt of names for each term. In conclusion: (1) Draw an imaginary picture illustrating each term. (2) Using paper mache or other pliable material, make a relief map illustrating each term.

3. Leading Question: When icebergs melt, why doesn't the ocean overflow?

Materials: Water glass, ice cubes

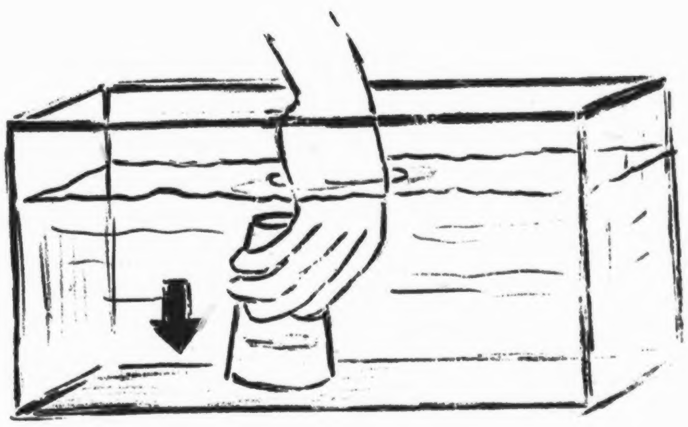
Procedure: Put an ice cube in a glass, then fill the glass to its brim. When the ice has melted, examine the water level. The glass will not overflow because ice displaces more volume than the weight of the same amount of water. When the ice melts, the total volume decreases. Compare with an iceberg.

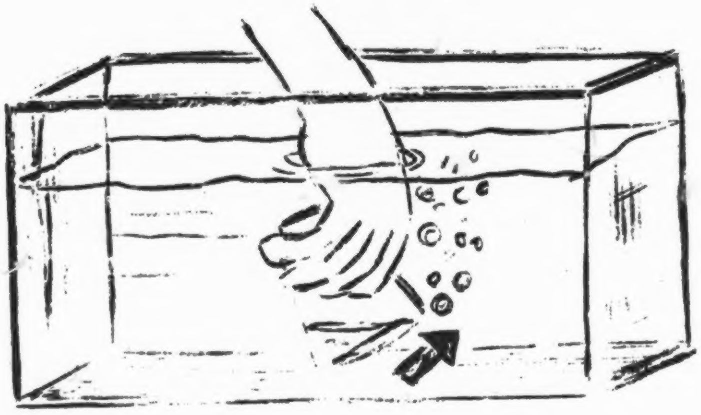
4. Leading Question: How do you think ancient people explored the ocean?

Materials: Glass, aquarium tank

Procedure: Have a child push a glass of air upside down into an aquarium filled with water. Observe what happens. Tip the glass slightly and observe again. Ask the children to explain what happened and why it happened. Ask how ancient peoples might have used this idea to explore beneath the ocean.

Research: Greek diving bell
Ancient maps of the ocean
Legends of the ocean





5. **Leading Question:** Is there any place you know of where you can go swimming and not sink?

Materials: Beaker, scale, china marking pencil, salt

Procedure: The Great Salt Lake, the Dead Sea, and the ocean provide non-swimmers with built-in life preservers. Locate these on a map. Have the children do research to obtain a definition of density. Discuss the difference in volume between a ton of rocks and a ton of cotton.

The relationship between salinity (salt content) and density can be illustrated as follows: Put a beaker on a scale, weigh it, and then fill the beaker from the total weight. Mark the water level on the beaker with a marking crayon. Now add several tablespoons of salt to the water and stir to dissolve it. Record the new weight. The following conclusions should be discovered.

a. The water will weigh more.
b. The water will occupy more space.
c. The water will be more saline.
d. The water will be denser.

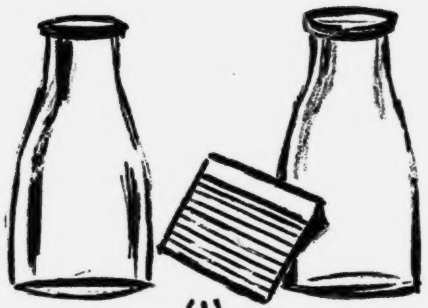
6. **Leading Question:** What makes a current move?

Materials: Two quart bottles of equal size, salt, food coloring or ink, hot and cold water, index card

Procedure: Bottle #1 should be filled with cold water. Bottle #2 should be filled with tinted (use ink or food coloring) hot water. Place an index card over the mouth of the hot water bottle and then invert it on top of the cold water bottle (see drawing). Holding the bottles tightly together, place them on their sides. Have the children appraise the ensuing events when the cardboard is removed.

Repeat experiment using cold water in one bottle and cold, tinted salt water ($\frac{1}{4}$ cup). Have the children infer that temperature difference or salinity cause ocean current.

Note to teacher: Convection is the process when heated material is pushed by colder matter.



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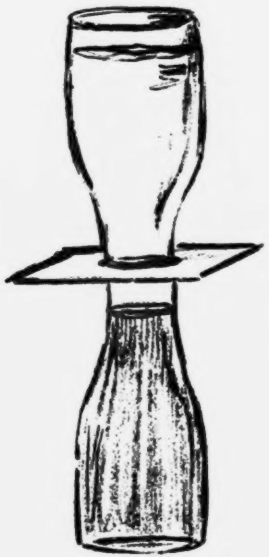

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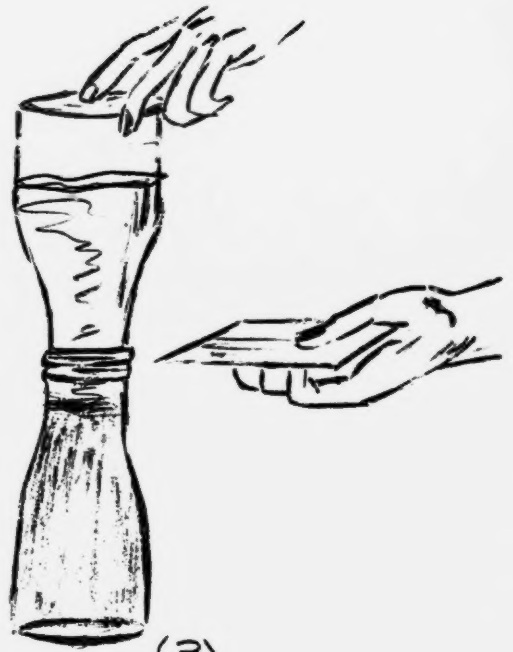

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7. Leading Question: Is pressure greater at the surface or bottom of the ocean?

Materials: Milk carton or large coffee can, water, tray

Procedure: Punch holes in one side of the container at one inch, three inch, and five inch levels from the bottom. Hold the container over a tray. Fill the container with water. Make observations concerning the streams of water pouring from the holes.

8. Leading Question: How does nitrogen in the blood cause the bends?

Materials: Bottle opener, two bottles of soda pop

Procedure: Have a child pry off the cap of a soda bottle very gently. Through class observation, draw the conclusion that the bubbles of gas rise slowly to escape from the bottle. Pry the cap off the second bottle very suddenly. Compare what happened to the second bottle in relation to that of the first. Pose the question of how this has relationship to a deep sea diver who has nitrogen (gas) in his bloodstream. Have the children discover what effects are felt from the bends. Have the class infer how the bends can be avoided.

Note to teacher: Children should know that nitrogen increases in the blood under extreme diving pressure.

9. Leading Question: How can we drink sea water?

Materials: Bunsen burner, flask, water, salt, filter paper, evaporating dish

Procedure: In a cup of warm water dissolve four teaspoons of salt. Cool the water to 30° F (use a salt and ice pack). Then filter as much salt from the water as possible using the filter paper. Test to see if the water tastes salty. Next, evaporate the water. See if there is any salt remaining.

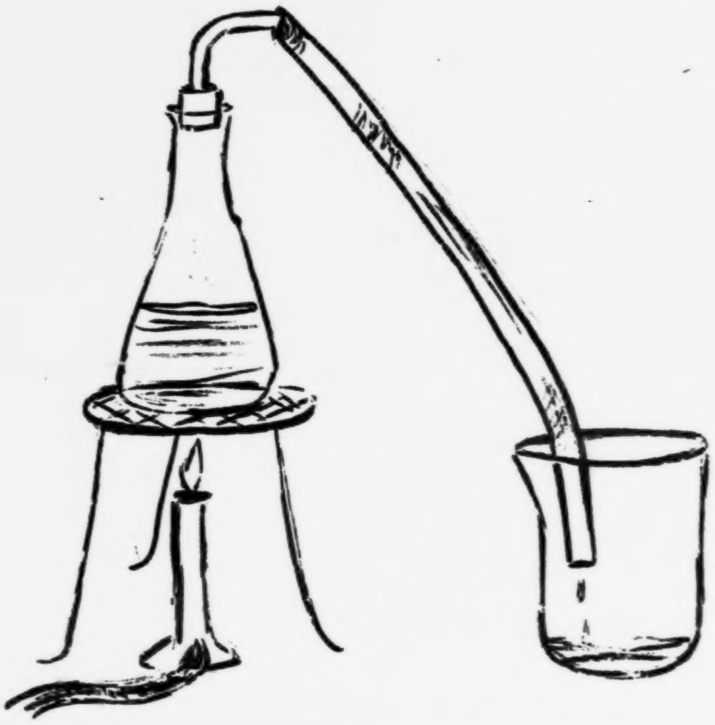
Note to teacher: Be sure equipment is clean. The tastebuds are a good scientific test, but precautions should be taken in the classroom as a safeguard to health.

10. **Leading Question:** Would you like to drink boiled sea water?

Materials: Heat source, two flasks, rubber stopper, glass tubing, rubber hose, salt, food coloring or ink, water distillation

Procedure: In a flask dissolve four tablespoons of salt in a cup of warm water. Heat the water passing the steam through a rubber tube into another container. Have a child taste the distilled water to test for salinity. Repeat this experiment using food coloring to tint the water in order to show that other impurities can be removed by distillation.

Note to teacher: Do not allow children to taste water unless all equipment used is clean (preferably never used before).

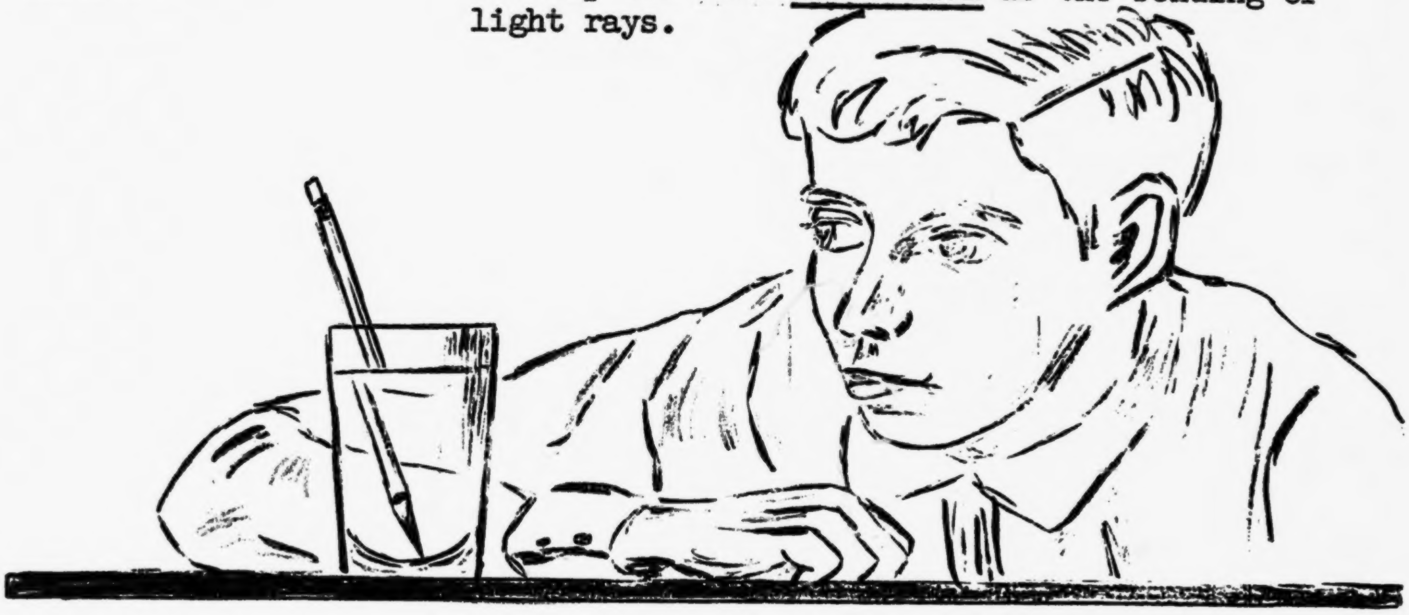


11. Leading Question: Do divers see as well under water as they do on land?

Materials: Water, glass, pencil

Procedure: Fill the glass with water. Place a pencil in the glass and look at the pencil through the water. Allow the class to draw a conclusion and relate this to the leading question. Have someone describe what has happened to the pencil and why it happened. Suggestions can be made from the group as to how this might pose problems to a diver.

Note to teacher: Develop the word refraction as the bending of light rays.



12. Leading Question: Do icebergs and glaciers add anything to the ocean besides water?

Materials: Freezer, milk carton, stones, gravel

Procedure: To illustrate that icebergs and glaciers deposit sediment in the ocean, have a volunteer perform the following activity:

In a milk carton filled with water, add a few small stones and gravel. Freeze the contents. In a large glass container, float the block of ice and stones. Have the children observe the deposition of stone and gravel.

Note to teacher: This activity might be a contribution to the class by a less able child. Also see related activity #13.

13. Leading Question: How much material can an iceberg carry?

Materials: Ten $\frac{1}{2}$ pint milk cartons, small stones and gravel, aquarium, balance scales

Procedure:

Into ten $\frac{1}{2}$ pint milk cartons put various amounts of water. Subtract the weight of the empty carton from the weight of the water to obtain an accurate weight. Number each carton. Now add an amount of stone and gravel to each one. Weigh the quantity and add to the weight of the water. Freeze the cartons. Have the children predict which will sink or float the best.

After freezing, have the children remove the paper carton from the "iceberg". Float each "iceberg" individually. Examine the position of each in the water. Measure the portion of each "iceberg" above the water surface. Do some sink? Why? Chart the results. What would happen if the "icebergs" were floated in a heavy brine (salt solution)?

Use the metric system to weigh materials.

14. Leading Question:

How does a corer tell us about the ocean floor?

Materials:

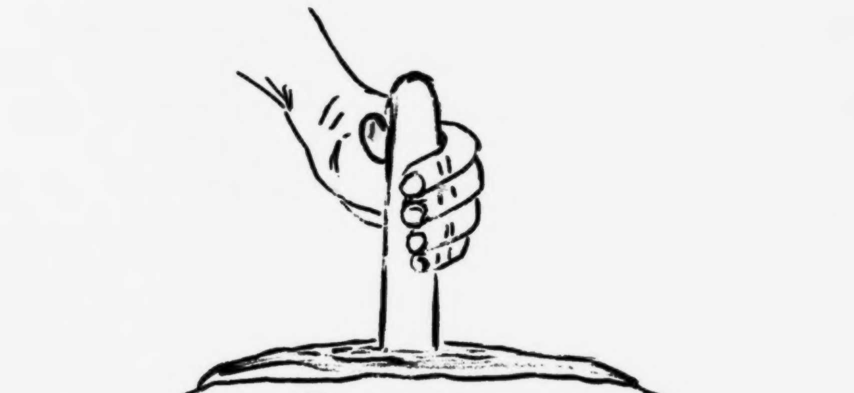
Test tube or cardboard tube, colored clay, paper plate or newspaper

Procedure:

Arrange the clay in different layers of different colors. Cover the entire lump of clay with the same color. Let a child describe the make-up of the section of clay. Take the test tube, open-end first, and push it into a section of the clay, turning it from side to side until it hits the bottom. Carefully remove the test tube from the clay lump and examine what has been discovered. Draw conclusions as to how this is related to the corer and what it tells scientists.

Note to teacher:

A corer is a long steel tube forced into the bed of the ocean.



15. Leading Question: What is sediment?

Materials: Children's choice

Procedure: Construct a model of ocean sediment from painted plaster, clay, paper, or chalkboard illustration. Include sediments from the following: rivers, volcanoes, icebergs, glaciers, particles from the air, meteors or "shooting stars", remains of plants and animals, refuse from man.

Make a three-demensional exhibit using materials of different types, sizes, and weights. Tall jars, such as olive jars, are the best containers. Add water to the materials in the jars and shake. Use as many colors as possible.

16. Leading Question: What "monsters" live in the water but can't be seen?

Materials: Fine-meshed cloth, magnifying glass, microscope or microprojector

Procedure: Drag a fine-meshed cloth through the water of a pond. Examine this material through a magnifying glass, or mount it on a slide and examine it under a microscope or microprojector.

Note to teacher: This experiment might also be done by writing letters to students in a school near the ocean. The class could ask them to perform experiments with the ocean and trade the results for information on Bethlehem, the Moravians, or the steel and cement industries.

17. Leading Question: Who eats whom?

A. Materials: Pieces of oaktag, felt pen, string, punch

Procedure: Set up a classroom food chain. Have the children make signs to hang around their neck bearing the names of various sea animals and plants. Include such names as phyto plankton, zoo plankton, shark, lobster, whale and others that the children may suggest. Have the children attach string to the oaktag so that the name of the animal or plant will show when they put the sign around their neck. Beginning with the smallest or largest animal, have them pick out who they feed upon and keep the chain or cycle going from there. This might be compared to a similar cycle on land.

B. Materials: Various art supplies, depending on choice of the class

Procedure: Make a chart, bulletin board, or mural of the food cycle showing the interdependence of plants and animals in the food chain of the sea. Children can draw, cut, or paint, the objects and place them in their proper position.

18. Leading Question: What makes a wave?

A\. Materials: Shallow pan, three-speed electric fan, water

Procedure: Fill a shallow pan with water. Turn the fan toward the water and observe how the surface is set in motion. Increase the speed of the fan and note what happens to the little waves. Add a rock to the water and repeat activity. How does an obstruction affect the waves?

Note to teacher: Danger! Discuss safety measures involved with the use of a fan.

B\. Materials: Wave Motion Lab (Central Science Materials Library)

Procedure: Use the Wave Motion Lab material to show how waves travel in water. Investigations are included with the Lab.

19. Leading Question: How far below the surface of the ocean does one find waves?

Materials: Aquarium, oaktag, water, food coloring

Procedure: Internal waves can be illustrated by half filling a glass tank with a saturated solution of salt water (as much salt as the water will hold). On the surface lay a piece of oaktag and pour an equal amount of colored tap water into the tank. The paper will keep the liquid from mixing, and when removed will allow the children to see two distinct layers.

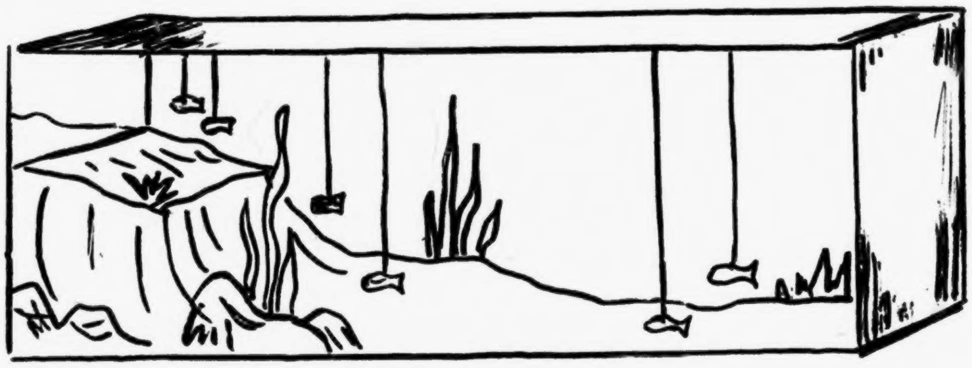
Carefully remove the oaktag. Now, gently move the tank back and forth. Examine the place where the two liquids meet. Can you see the waves? Try the same experiment using oil and water.

Note to teacher: Different densities of water, at the surface and at the bottom, cause internal waves to develop in the ocean.

20. Leading Question: What organisms live at different depths in the ocean?

Materials: Cardboard box (soup boxes are good), thread, paper, clay

Procedure: Make a diorama of the ocean which will illustrate the different kinds of animals and plants that live at various depths. Cutouts of these plants and animals may be hung by threads extending to the proper depth.



Paint a suitable background based on research.

Note to teacher: Soap or clay models might be used at the bottom of the "ocean".

21. Leading Question: What is a possible way nodules are formed?

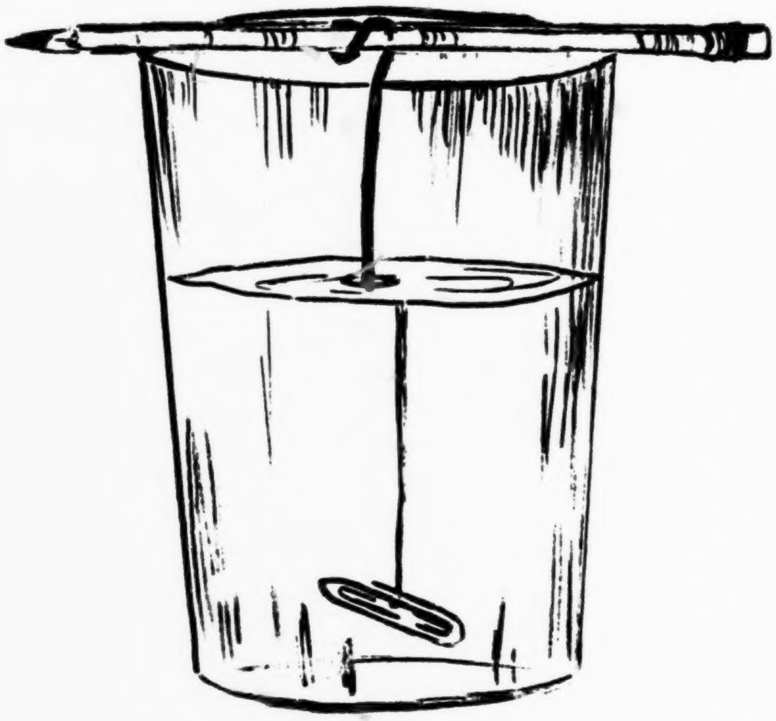
Materials: Teaspoon, copper sulfate, water, glass, paper clip, string, pencil

Procedure: CAUTION: Do not taste the material in the glass. It is a POISON!

Put a cupful of water in a glass and add two teaspoons of copper sulfate. Crystals will form in the water. Hang a paper clip in the solution as illustrated. Let the solution set for a few days and observe what has happened. Relate this to nodule formation.

Note to teacher: Scientists are still experimenting in nodule formation. Make it apparent that perhaps metals in seawater turned to nodules when there was a solid for them to cling to.

Copper sulfate is available from Central Science Materials Library or School Science Room.



22. **Leading Question:** How do we depend on the sea?

Materials: Magazines, newspapers, pamphlets

Procedure: A bulletin board showing foods we get from the sea will illustrate the economic importance of the sea.

23. **Leading Question:** How are minerals taken from the sea?

Materials: Limewater, plastic tubing, flask

Procedure: To demonstrate collection by chemical change, fill a flask with limewater. Blow in the limewater through a tube. The carbon dioxide from your breath combines with some of the lime to form a chemical compound which will not dissolve in water. Let the water stand and it will settle out. The carbon dioxide and the lime in the water have combined to make stone - limestone. Compare this type of method to a similar method which might be used in mining the sea.

24. **Leading Question:** What is the formation of sedimentary rock in the ocean?

Materials: Pint of soil, pint of pebbles, gravel, sand, two quart jar, water

Procedure: Place the soil, pebbles, gravel, and sand into the glass jar. Add water to almost fill the jar. Stir the mixture very thoroughly and let it stand. Observe how the sediment settles and why it forms in this way. Compare this sediment to sedimentary rock in the ocean. Help the children to discover that pressure is the missing ingredient.

25. **Leading Question:** How can the weight of water be calculated?

Materials: Bathroom scale, bucket, water

Procedure: Make the following chart in order to record data:

Weight of the bucket ____________________

Weight of the water and the bucket _______

Weight of the water ____________________

Pressure of one cubic foot of water ______

Pressure of two cubic feet of water ______

Put the empty bucket on the scale. (If a bathroom scale cannot be obtained, the scale in the school health room would also serve the purpose.) Record the weight of the bucket. Add four quarts of water (one gallon) to the bucket and record the weight. Compute, by the use of subtraction, to record the weight of the water.

Seven and one half gallons of water will equal one cubic foot of space. How much will one cubic foot of water weigh? What will be the pressure on the bottom of a cube of water that measures one foot by one foot? What would happen to the pressure at the bottom if you put one cube of water on top of the other?

Compare the weight of sea water and the pressure found at various depths.

26. **Leading Question:** How do mineral deposits form nodules?

Materials: Two 1,000 ml. beakers, one-half cup copper sulfate crystals, water, two Bunsen burners, teaspoons, large metal tray, paper toweling, 500 ml. graduate, two Celsius thermometers (Centigrade)

Procedure: By the use of the graduate, pour 500 cc of water in each beaker. Heat the water until it is about 100°C. Place both beakers on several layers of paper that are on the metal tray. Stir some copper sulfate crystals into both beakers. Put the sulfate in a spoonful at a time until no more dissolves. Make a record of the time. Drop one copper sulfate crystal into the first beaker and do not move either beaker.

Observe both beakers at ten minute intervals until the solutions cool to room temperature. Add another crystal to the beaker that has the extra crystal in it. Compare what has happened in each beaker and conclude what effect this has upon the nodules found in the sea.

27. **Leading Question:** What does the bottom of the ocean look like?

Materials: Four by eight sheet of plywood, sand, stones, gravel, clay or plaster, hydrographic relief globe

Procedure: Make a topographical map of the ocean bottom. Use sand, stones, and gravel on the four by eight sheet of plywood. Have the children research all the possible types of ocean bottoms and include these with appropriate labels. Have them show the form of the continents, the continental shelves, the slopes and the terrain of the ocean floor.

A diagram of the Atlantic or Pacific and the Hydrographic Relief Globe can be used as a guide in construction of underwater mountain ranges, trenches, canyons, and volcanoes. Plaster or clay can be used as a molding basis for the model.

28. **Leading Question:** How far is it between the top of the highest mountain and the bottom of the deepest ocean gorge?

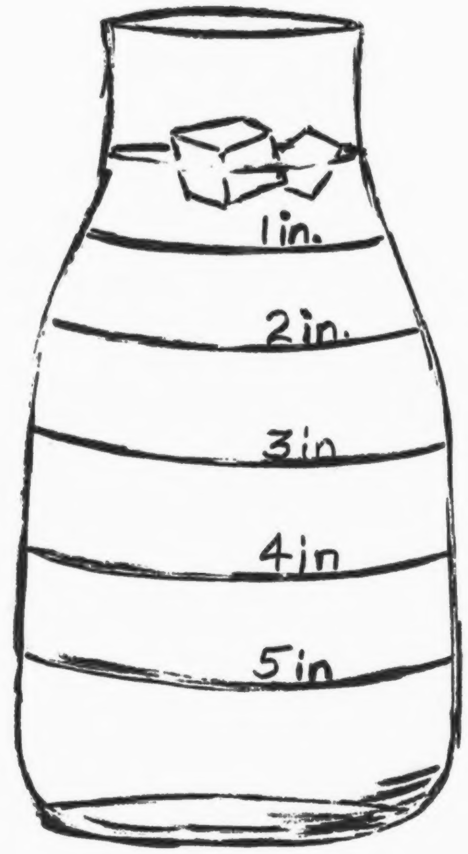
Materials: Paper, crayons, research books

Procedure: Make a line graph showing the heighths of various mountains and the depths of the famous sea trenches. Label the well known ones.

29. **Leading Question:** How do scientists determine the temperature of the ocean?

Materials: One large jar, ice cubes, china marking pencil or transparency grease pencil

Procedure: Fill a large jar with water. With a ruler and a china marking pencil, mark units of measure on the jar. Float some ice on the top of the water. Have the students record the temperature at different depths and explain their observations.



30. **Leading Question:** How does a hydrometer work?

Materials: Water, glass, sand or gravel, test tube, paper, alcohol, gasoline, kerosene, milk, salt water

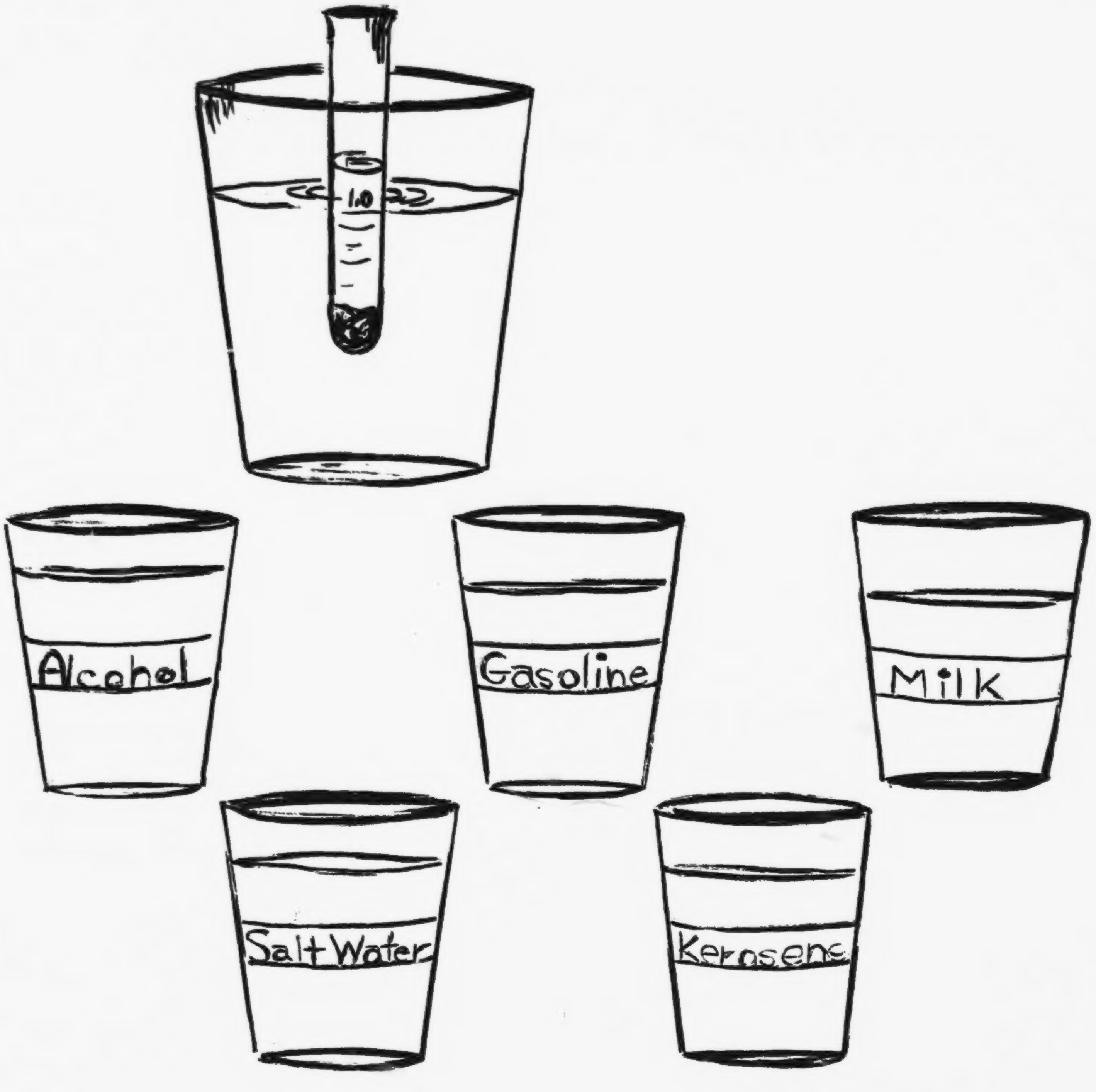
Procedure: Put enough sand or gravel in a test tube so that it stands upright in a glass of tap water. When the test tube is submerged to half its length, the best results are obtained. Roll a piece of paper to fit into the test tube and mark "1.0" at the level at which the test tube floats in the tap water.

Now try the hydrometer in the following liquids and mark the scale accordingly. All liquids should be at room temperature. The known densities for these liquids can be checked with the class findings.

Alcohol - 0.79
Gasoline - 0.68
Kerosene - 0.8
Milk - 1.03
Salt water - 1.025

The hydrometer can also be tried in very hot or cold liquids. Draw conclusions as to why the hydrometer reacts differently in the solutions. Definition: Hydrometer - an instrument used to measure the density of liquids.

Note to teacher: A scientifically accurate hydrometer is available through the Central Science Materials Library.



31. Leading Question: How does the moon cause tides?

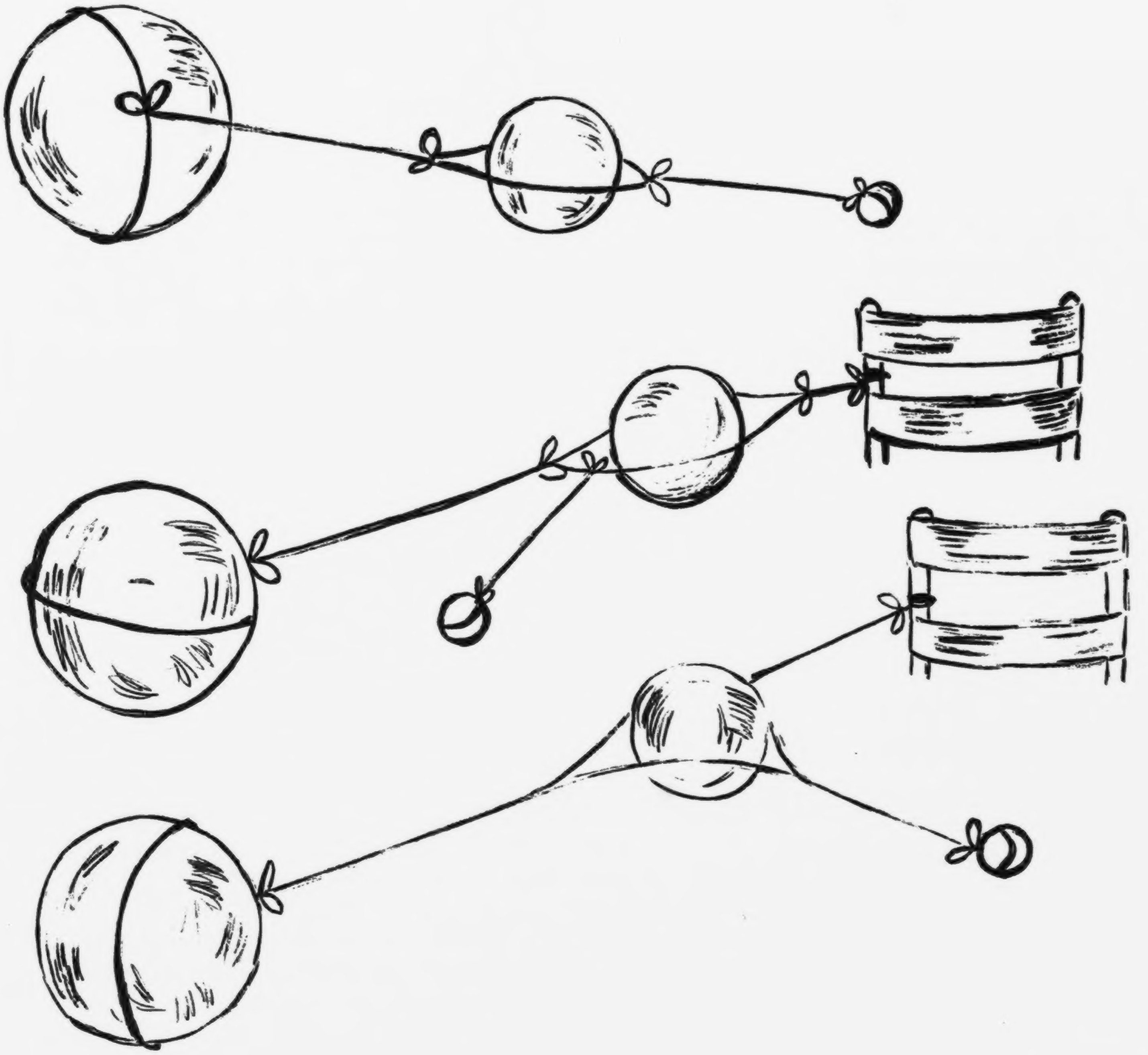
Materials: Large ball (sun), small globe (earth), small ball (moon), large rubber band, long and short piece of string

Procedure: Fit the rubber band around the globe and tie the two pieces of string on opposite ends. Tie the free end of the shorter string to the "moon" (Scotch tape will secure it firmly). Tie the free end of the longer string to the "sun". The rubber band around the "earth" represents the ocean and the string on either end represents the gravatational pull of the moon and sun. Put the globe in position so that the Atlantic Ocean is facing the moon. Rest the balls and the globe on the table and have a child hold the sun in position while another child pulls on the "moon". Discuss where high and low tides would be!. Draw conclusions as to the effect of the sun on the tides.

The moon can be placed in various positions to illustrate spring tides and neap tides. See illustrations.

Note to teacher:

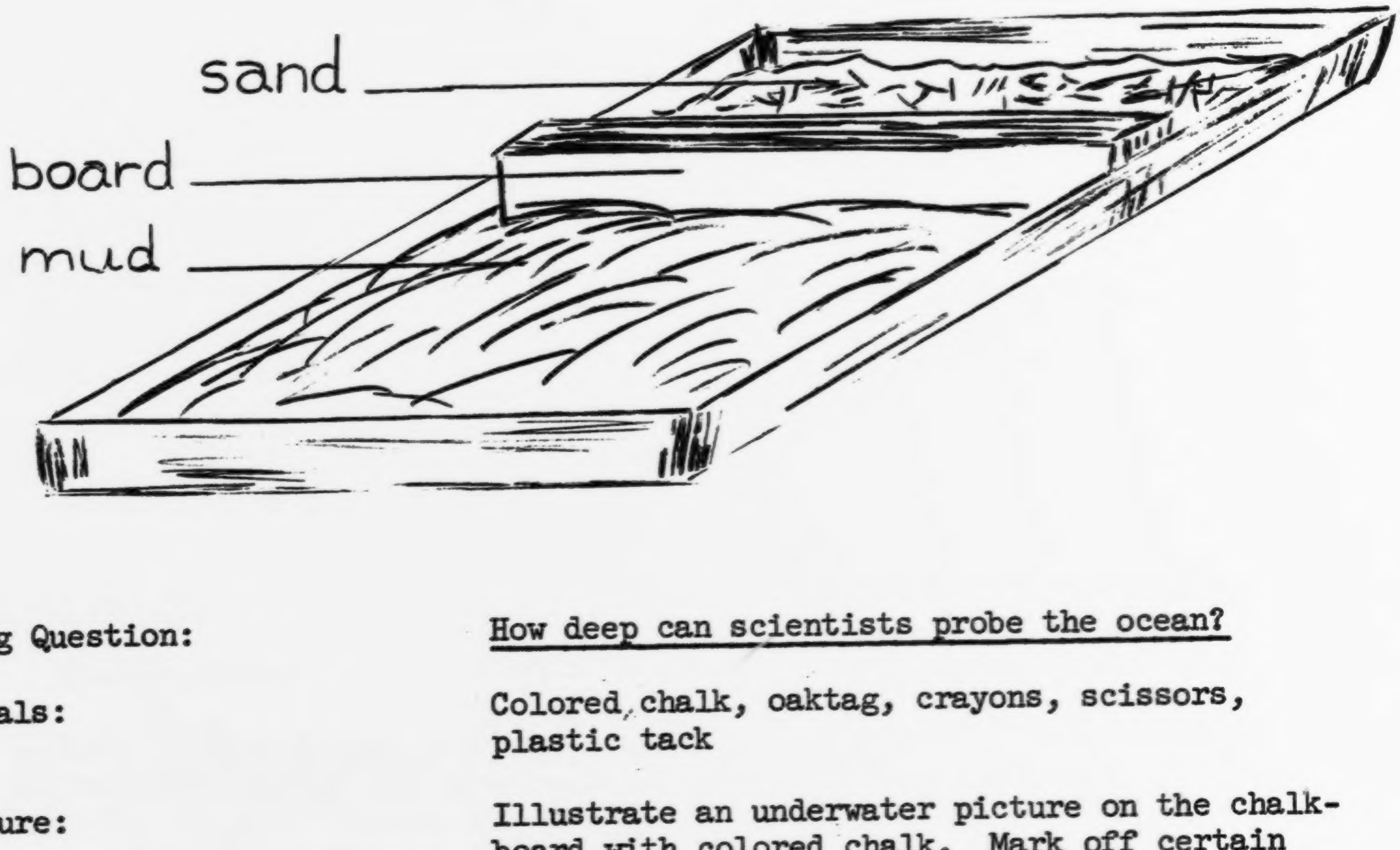
Spring tide is only in name. This occurs at certain times of the month when the sun and moon are so lined up that they pull together causing a very high tide.



32. Leading Question: How does the action of the shoreline affect the shoreline?

Materials: Long shallow pan, board five inches wide, soil, sand

Procedure: In a long shallow pan fill a five inch space at one end with soil using a board (the height and width of the pan) to hold the soil in place. Add water to this soil until it becomes a mud. Pack the soil solidly and allow to dry for a few days. After the soil has dried, put a two inch layer of sand in the pan so that the board separates the mud and the sand. Add one and one-half inch of water to the sand and remove the board. Move the board back and forth in the water. Watch the waves "beat" against the shore! Does some of the "shore" wash away? Draw other conclusions.



33. Leading Question: How deep can scientists probe the ocean?

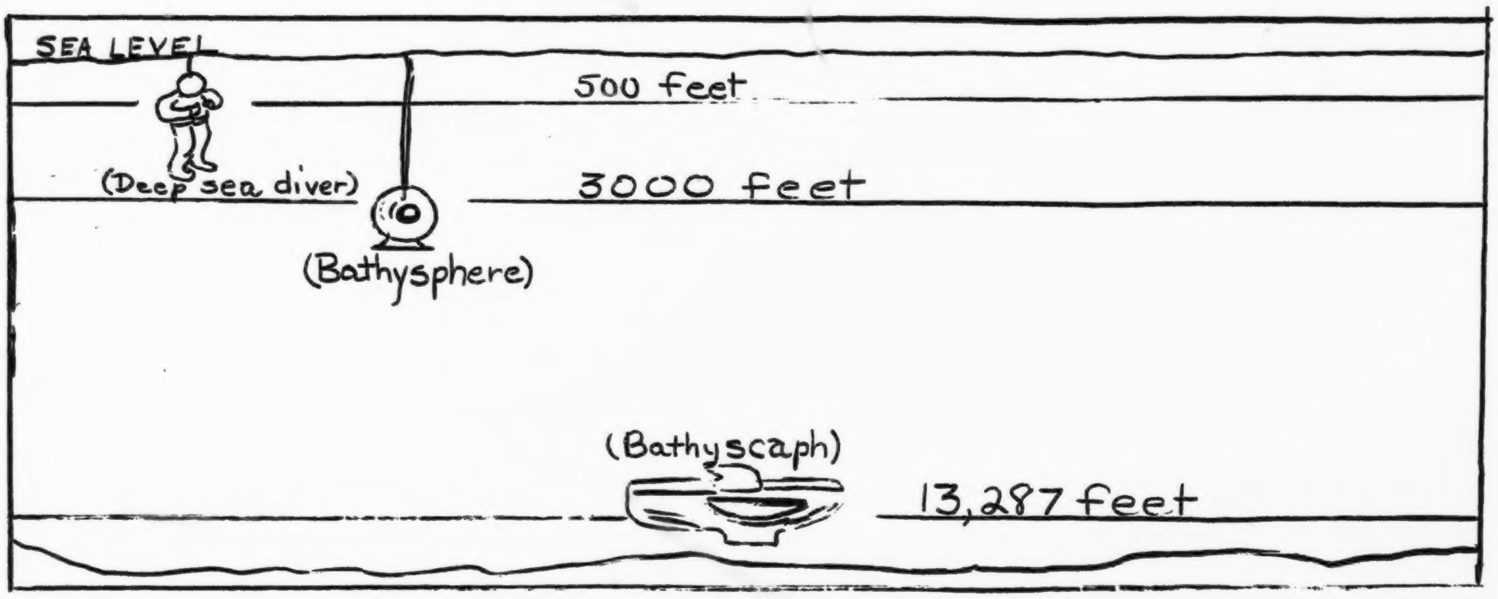
Materials: Colored chalk, oaktag, crayons, scissors, plastic tack

Procedure: Illustrate an underwater picture on the chalkboard with colored chalk. Mark off certain measurement lines (see illustration). Using oaktag and crayons have certain children draw various pictures of types of equipment used in underwater exploration. Some might include:

- corer
- grab bucket
- plankton townet
- nansen bottle
- scuba diver
- deep sea diver
- armored diver
- bathysphere
- bathyscaphe
- underwater camera

Any other suggestions from the children should be accepted. Have the children color and cut out the pictures. Then have them do research to find out the depth at which their illustration can function. Plastic tack will hold the picture to the board. It will also allow movement of the objects. The activity might also be adapted to the bulletin board with pins making the project mobile.

Discussion: Why do some types of equipment function only in shallow water? What happens to divers who ascend too quickly? Why?



Note: Refer to Appendix - page 213 - The Ocean with World Record Depths.

34. Leading Question: Can you find the microbes of the deep?

Materials: Microscope, microprojector, slides

Procedure: Use prepared slides of algae, diatoms, etc. (available in the Central Science Library or your Science Room). Observe microscopic organisms through these instruments. Compare these organisms with those pictured in resource books. Allow children to use the microscopes in their own time to locate objects.

Question: Are fresh water organisms similar to those of the ocean?

35. Leading Question: Can you find the sea animals?

Materials: Bioplastics from the Central Science Materials Library

Procedure: Obtain the bioplastics from the Central Science Materials Library. The following are available concerning the ocean: skate, crayfish, trout, sea horse, octopus, starfish, corals, snail. Mix the ocean group bioplastics with a group of land animals, also bioplastics. Formulate a list of those animals which belong to the sea. Discuss why they would live in that environment, some of their characteristics, and compare them with land animals.

36. Leading Question: What specific tools and equipment does the oceanographer use?

Procedure: Have a group of children obtain pictures or illustrate the tools and equipment of the oceanographer. These should include the dredge, the plankton townet, nansen bottles, the bathythermograph, the corer, the echo-sounder, seismic sounding, drift bottles, and other equipment recently invented.

The able learner might explain and demonstrate how a submarine operates. This child could also make models of some of the more complex equipment.

The slow learner might show the visual differences between a submarine and a bathyscaphe or explain why underwater cameras must be made differently than the cameras used on land.

37. Leading Question: How can we find out more about the Continental Shelf?

Materials: Paper of class choice

Procedure: Chart the Continental Shelf (depth and breadth) from Newfoundland to Cape Hatteras. Discuss the following questions:

> What life is supported by the water of the Continental Shelf?
>
> How and of what is the Continental Shelf formed?
>
> What are the Grand Banks?

38. Leading Question: What is beneath the ocean's sediment?

Procedure: Chart a cross-section of the ocean floor and crust. This might be a good bulletin board project. The chalkboard might also be an exciting medium. Compare the crust of the ocean bottom with the crust of the earth on land.

39. Leading Question: How could man live under the sea?

Materials: Construction paper, crayons

Procedure: This should be used as a culminating activity to finish the unit. Have the children design their own underwater home and back up its working through scientific knowledge they acquired during the unit. Rooms of the house should be included and all parts should be explained. One or two students ideas can be selected from the class to be put on a bulletin board.

40. Leading Question: Will an egg float?

Materials: Egg, beaker, warm water, salt

Procedure: Sink an egg into some warm water partially filling a beaker. Add salt to the beaker slowly. Have the children explain why the egg rises. Discuss the relationship of this experiment to the ocean. Try the experiment using sea salt available from a drug or health store. Measure the amount of salt used and the results from differing amounts can be charted. Compare this activity with activity Number 30 and icebergs.

ACTIVITIES TO ASSIGN FOR HOMEWORK OR INDIVIDUAL RESEARCH

41. Leading Question: Why are some animals and plants particular about where they live?

Procedure: Make a sea-life picture map of the United States waters. Compare this with a map of other different areas such as near the equator. Develop a list of factors which make up an ocean environment, such as: salinity, density of minerals, depth, temperature, availability of light, etc.

42. Leading Question: What are the rivers of the sea?

Procedure: Have children map the ocean currents of the world. Research should be done to discover how these currents were discovered. Children should discover how man utilized these currents years ago. They should gain an awareness of the importance of these currents because of their effect on the climate of land areas.

An interesting project might be to show how sea life utilizes these currents. Icebergs, furthermore, are tracted through a knowledge of these currents. Man's utilization of currents can be discovered in Kon-Tiki by Thor Heyerdahl.

43. Leading Question: Do the tides of the ocean rise and fall at the same time everyday?

Materials: An almanac, newspapers of the day

Procedure: Have a group of children collect and chart tidal information for the period of one month. These can be gathered from an almanac or the New York or Philadelphia papers.

Collect sailing times of ships for the same period. Have the children try to discover a relationship between the two sets of facts.

For extended study: Was there a greater relationship between these facts in the days of sailing ships? Why?

44. Leading Question: Of what value is seaweed to man?

Procedure: Have a group of children investigate seaweed and reports on the different kinds useful to man such as for food, paper, etc. Some food speciality shops might have canned seaweed to taste.

45. Leading Question: What are some ways that ocean islands are formed?

Materials: Reference books, chalk, crayons, and paper

Procedure: Have the children do research on various island formations. The origins of the Hawaiian, Bahama, and Canary Islands are good beginning points. Surtsey is one of the newest islands and there is a plentiful supply of information as in the "Nature and Science" (December 6, 1965).

Illustrations of each type can be made. Don't forget to include a question on how coral is an island builder.

46. Leading Question: How much sewage and garbage does one major city in one day dump into the ocean?

Procedure: A. Write to the departments of garbage and sewer disposal in New York or Philadelphia and find out about disposal methods.

B. Write to a leading newspaper of a major city and request their research department to answer your query.

C. Help the children discover that the sea is used as a dump for radioactive wastes. How has this problem affected fishing in the Atlantic by the British? Will this affect us in the future?

47. Leading Question: How do we measure the ocean?

Procedure: Make a chart comparing nautical measurements and land measurements. This activity might be correlated with a mathematics study.

Longitude and latitude might also be studied at this time. The instruments of navigators might also be discussed and diagramed.

48. Leading Question: Are there larger canyons than the Grand Canyon?

Procedure: Diagram the depth and extent of the spectacular Grand Canyon and compare it with diagrams of canyons which extend into the continental shelf. A good example is the Hudson River canyon which is the most completely surveyed submarine canyon in the Western North Atlantic. Send for Chart #1108, Approaches to New York, (one dollar each) U. S. Coast and Geodetic Survey, Washington 25, D. C., Chart #5101, San Diego - Santa Rosa is also of interest.

49. Leading Question: How can we study the origin of the earth?

Procedure: Divide the class into groups for the study of the topic. Provide for all levels of ability by using topics of interest for each level:

- Theories concerning the origin of the earth
- Ancient life in the ocean
- Geological evidences of the age of the ocean
- Atlantis: The Lost Continent
- Ancient maps of the sea
- Legends of the sea
- Oddities of the sea

50. Leading Question: What are some violent changes which affect the ocean?

Procedure: Research may be done on the famous tidal waves and their effects on the ocean and man. The famous storm, Diane (1955) is of local interest. The Bethlehem Globe Times has a special booklet which discusses the local situation.

Efforts of seashore resorts to maintain their beaches and, in fact, their existence might be explored.

51. Leading Question: Can we harness the ocean?

Procedure: There have been recent attempts to harness the tides for electrical energy. Diagrams and reports should be made on efforts of the French and the Passamaquoddy Project at the Bay of Fundy.

Information can be obtained from the various embassies in Washington, D. C.

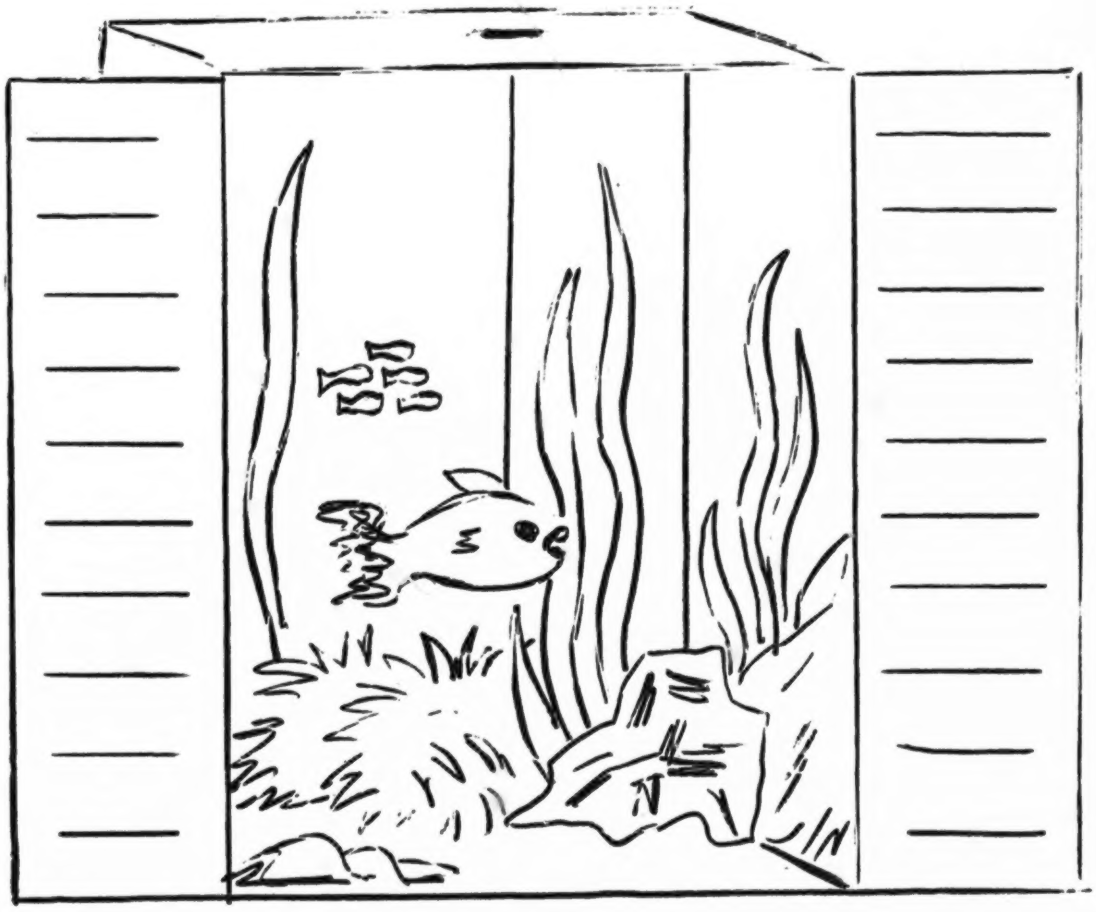
52. Leading Question: Did you ever meet a sea horse, shark, or octopus?

Materials: Cardboard boxes, construction paper, scissors, paste, thread, and research books

Procedure: Have each child choose an interesting sea animal that he would like to learn more about. The children may make their own suggestion or choose from the following list: sting ray, porcupine fish, shark, tuna, sea horse, star fish, sand dollar, salmon, eels, coelacanth, porpoise, dolphin, skate, sponge, seal, walrus, sea otter, barracuda, whale, clam, oyster, scallop, jelly fish, sea anemone, shrimp, lobster.

Each child should proceed to find pertinent information about his animal - such as characteristics, appearance, environment, food, and type of reproduction. This should be in written form.

Have each child make the inside of a box into a three-dimensional home for his animal. The animal then should be placed on thread and suspended from the top of the box so it appears to be swimming. Attach the report on the animal to the flaps of the box.



53. **Leading Question:** How can disaster benefit man's knowledge?

Procedure:

The attempt to recover the nuclear submarine, Thresher, utilized a great deal of deep-sea equipment. The newspapers and magazines of the day provide much information about this equipment.

The less able child might provide interesting material in reports concerning ship wrecks and salvage operations. The Barrier Reef of Australia and Cape Hatteras, North Carolina are good starting points.

54. **Leading Question:** How does man benefit from the sea?

Procedure:

Groups of children might present to the class the results of their research concerning the uses of the sea. The fishing industry is a large and open area to research. Factories on ships are common to this industry. The history of the whaling industry can be used in conjunction with a social studies unit. The latest techniques of farming at sea (aquaculture) might be discussed. The Japanese are among the greatest users of the sea. The oyster industry in this country is also of interest because this industry has been faced with the problem of pollution. The life cycle of an oyster is an interesting topic. The salmon is also a topic for an interesting discussion.

Other groups might research the process of extracting chemicals from the sea. The search for nodules containing minerals is a good research topic, as is off-shore oil drilling. In both cases models can be made by the less able learner.

DIGGERS TO DIVERS

Geology

Grade 6

Geologic Changes

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Geologic changes, brought about by heat and pressure within the earth, build and level the land.	1,2,3
Accumulation of sediment, (sedimentation), movements of rocks (diastrophism), and volcanic activity (volcanism), are building processes.	4,5
Sedimentation is the accumulation of sediment on the floors of lakes and oceans.	6
Diastrophism is the rising and sinking of the earth's crust and other changes in the position of the rocks.	1,5
Faulting is a break or crack in a rock layer.	7
Folding is the bending of rock masses.	8,9,10
Earthquakes occur when there is a sudden slipping of rocks along a fault.	1
Scientists use a seismograph to study earthquakes.	11,12
A tsunami is a huge wave of water caused by an earthquake.	13,14
The balance between the pushing up and the wearing away of the earth's crust is called isostasy.	1,15
Volcanism occurs when repeated eruptions of magma rise through the interior of the earth to the surface of the earth.	16,17,18
Volcanoes build two different types of mountains.	18
Mountains are classified according to the way they develop: block, folded, volcanic, and dome.	7,18,19,20,21
Wind, water, ice, abrasion and weathering are among the forces of erosion which help the leveling process.	22,23,24,25,26,27,28
Man can control erosion.	29
Earthworms and animals renew the soil.	30

DIGGERS TO DIVERS

Geology — Grade 6

Glaciers

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Glaciology is a study of glaciers of the past and the present.	
A glacier is a field of snow and ice that does not completely melt away in summer.	31
Glaciers form when more snow falls in winter than melts in summer. (recrystallization)	31
There are two main kinds of glaciers: valley glaciers and continental glaciers.	
As a glacier passes over an area of land, it scratches and digs in the land, carrying great amounts of soil and rock with it.	32,33,34,35
Moraines, or small hills, are formed when glaciers melt and rocks and soil are deposited.	34,35,36
Great chunks of ice break off glaciers and drift away as icebergs.	35,37
Cliff glaciers, remnants of a valley glacier, hug the shaded sides of mountains.	35
There are many evidences today of the ice ages.	35,36

DIGGERS TO DIVERS

Geology

Grade 6

Streams - Water

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Water is one of the most abundant and useful compound found on the earth.	
Water is found in many environments and is continually transferred from one place to another.	39
Water is found in the atmosphere, hydrosphere and lithosphere.	
Most streams and rivers, regardless of size are constantly changing their flow patterns.	4
Streams cut downward, lowering and widening their channels.	38
The erosion cycle of a stream valley can be divided into three main stages: youth, maturity, and old age.	38
The rate and amount of stream erosion depends on many factors.	38
A water table is formed when water which soaks into soil reaches a layer of rock it cannot pass through.	40,41
Artesian wells are used as a source of tapping ground water.	42,43

DIGGERS TO DIVERS

Geology — Grade 6

Current Problems and Studies

UNDERSTANDINGS TO BE DISCOVERED	RELATED ACTIVITIES
Geologists use a varied number of maps to interpret temperature averages, industrial growth, agricultural production, transportation movements, wealth, magnetic variation, vegetation, and property value.	
Pollution of the air and water are major problems.	44,45,46
Some steps are being taken to reduce air and water pollution.	47,48
Natural resources are exhaustible.	49,50,51
Research must be accelerated to meet the needs and demands of an ever-increasing population.	47,48

DIGGERS TO DIVERS

Geology Grade 6

ACTIVITIES

1. Leading Question: How does the pressure inside the earth change the earth's surface?

Materials: Beach ball, air pump, large container, sand or soil

Procedure: Lay beach ball flat and cover with layer or layers of damp sand or soil. Pump up beach ball slowly. What happens? Why?

2. Leading Question: What do contour maps portray?

Materials: Learning Lab #170, Contour Mapping (Central Science Materials Library)

Procedure: Refer to Contour Map #3, Discovery Sheet K.7048. Contour Maps of Land Forms.

3. Leading Question: What names can we give to different types of contours?

Materials: Learning Lab #170, Contour Mapping (Central Science Materials Library)

Procedure: Refer to Contour Map #1, Discovery Sheet K.17045, Contours and Regions.

4. Leading Question: Why are streams and rivers constantly changing?

A. Materials: Large carton, sand, electric fan, rock or some other obstacle

Procedure: Remove the top and one side of a carton. Place the carton so that the open side faces the class. Pour a pile of sand into the carton. Turn the electric fan on the pile. Observe how the particles move. Place the rock in the path of the blowing particles and observe. This action is similar to that of the collection of sediment on the downstream side of a large boulder.

B. Materials: Earth Science Stream Table (Central Science Materials Library)

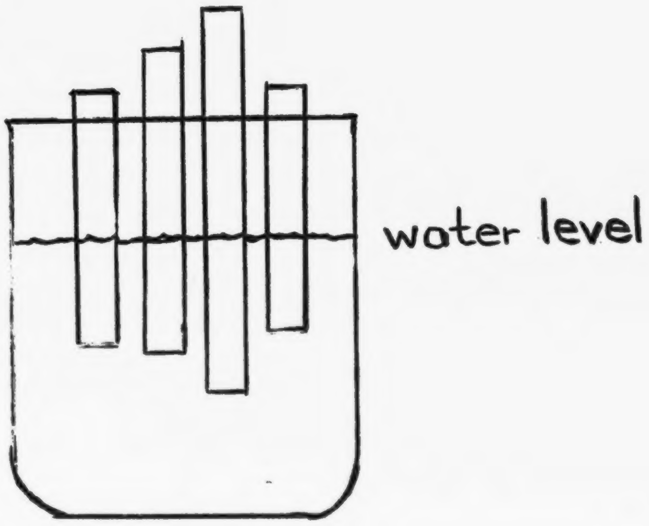
Procedure: Refer to investigations included with materials: stream table, wave generator, reservoir, recirculating pump and vinyl liner.

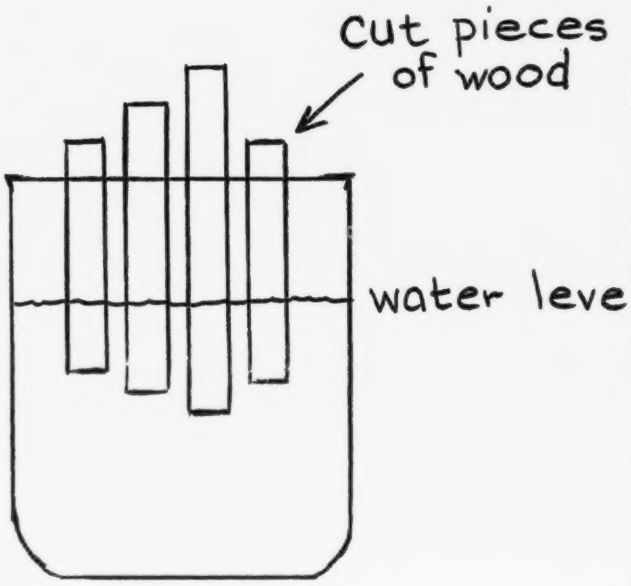
5. Leading Question: How does an up and down movement of the earth's crust leave an area higher than its surroundings?

Materials: Bell jar, four pieces of wood (1" x 5", 1" x 6", 1" x 4", 1" x 7"), water

Procedure: Place the pieces of wood into the bell jar of water, examining the level above and below the surface of water. Then remove a small piece of the wood block by sawing off the ends. Again place the wood blocks in the jar, observe level above and below the surface of water.

Note to teacher: When one material floats in another, the amount below the surface is proportional to the amount above. If part of the material is worn away or otherwise removed, part of the material below must rise above the surface to maintain proper balance.





6. Leading Question: How is sediment formed?

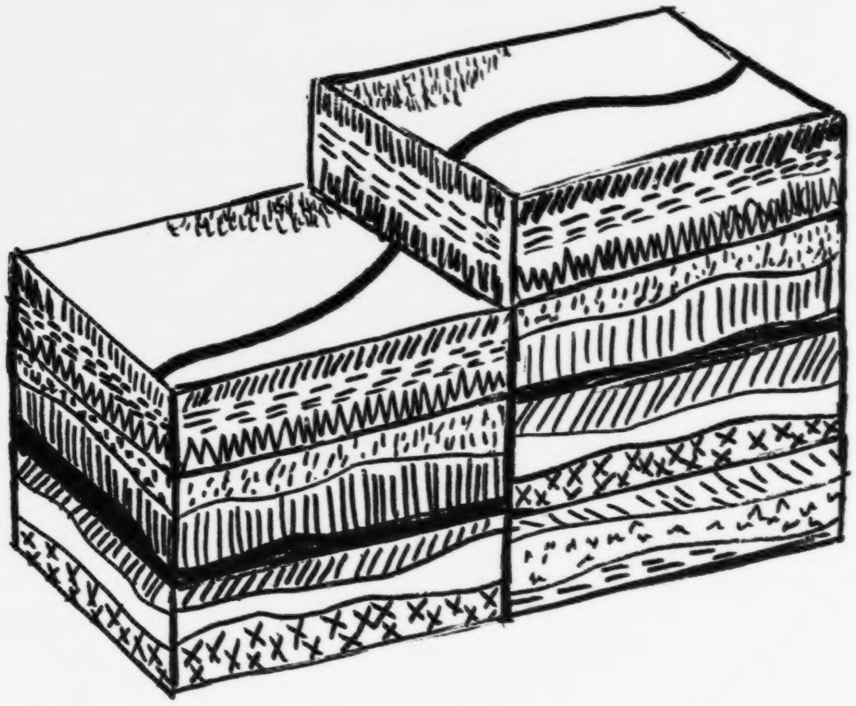
Materials: Large, clear glass bottle with a screw cap, soil, water

Procedure: Fill a bottle half way with soil, add water leaving a small air space at the top. Put the cap on the jar and shake it vigorously. Let the jar stand until all the soil particles settle. The largest pebbles will be at the bottom, smaller ones above and sand grains in the next layer. The materials that make up humus will float above the stones and sand.

7. Leading Question: What is faulting?

A. Materials: Empty boxes, Tempera paints

Procedure: Paint boxes to illustrate the layers of the earth crust. Stack boxes in two columns. Paint the boxes so that you have two that represent a continuous layer. Paint at least four boxes high. To illustrate faulting, remove bottom box from one column.



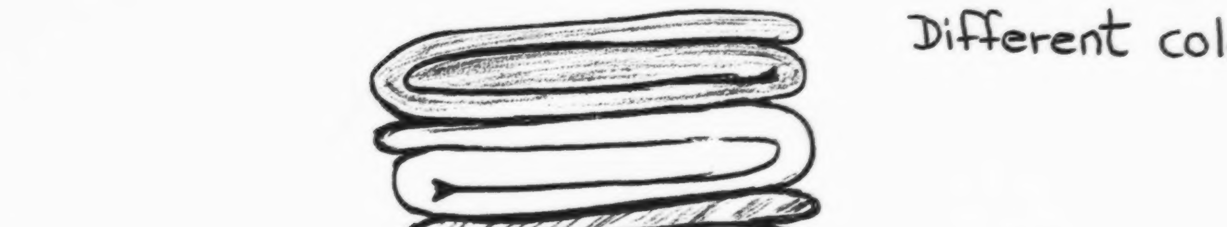
B. Materials: Geology Demonstration Kit (Central Science Materials Library)

Procedure: Materials can be assembled to demonstrate faulting and folding.

8. **Leading Question:** What effect does lateral pressure have upon the earth's surface?

Materials: Several different colored turkish towels

Procedure: Fold and stack the colored towels to represent the stratum of rock. With a hand at each side or end, gently push toward the center, or push in only one direction. Folds will appear and that portion of the earth's crust changes affected will be squeezed together and shortened.



9. Leading Question: How are rocks folded?

Materials: Three magazines

Procedure: Ask a child to place three magazines one on top of the other. Have the magazines facing the child, just as though he were about to read them. Imagine that the magazines and their pages are layers of rocks within the earth.

Have the child place his hands on the table, each hand touching a side of the pile of magazines. Have him move one hand toward the other. His hands will make a sideward pressure like the pressure in the earth. What happens to the magazines? The folds of the magazines between his hands represent mountains made by the folding of the surface of the earth.

10. Leading Question: How are mountains formed?

Materials: Several strips of colored paper or flannel cloth about two inches by two feet long.

A. Procedure: Cut several strips of colored paper or flannel cloth about two inches wide and two feet long. Superimpose one strip on another to represent several layers of rocks. With your hands placed at each end of the paper or cloth, push each end toward the middle.

Elevations and depressions will occur which illustrate the anticlines and synclines that occur in folded mountains. (Appalachians and Alps are examples of folded mountains.)

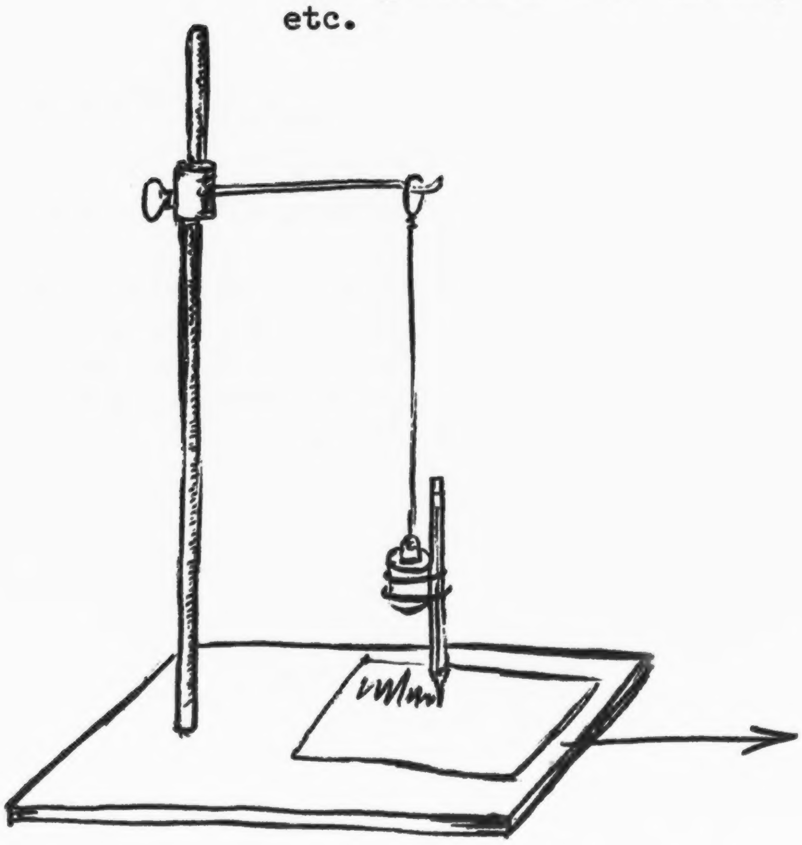
B. Procedure: Geology Models (Central Science Materials Library).

11. Leading Question: How does a seismograph work?

Materials: Ring stand, one pound weight, string, pencil, seismograph model (Central Science Materials Library)

Procedure: Secure a sharp pencil to the weight that is suspended from the ring stand. Adjust the pencil so that the point just touches a sheet of paper placed on the base of the ring stand.

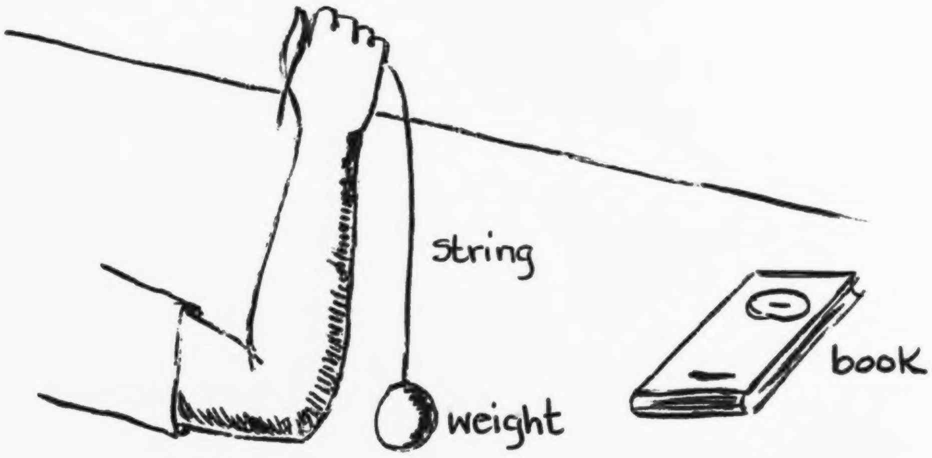
Pound on the table on which the make-shift seismograph is resting, pull the sheet of paper as you pound. Repeat with news paper, having someone walk heavily across the room, etc.



12. Leading Question: How does a seismograph record earthquake waves?

Materials: Table, string, weight, book

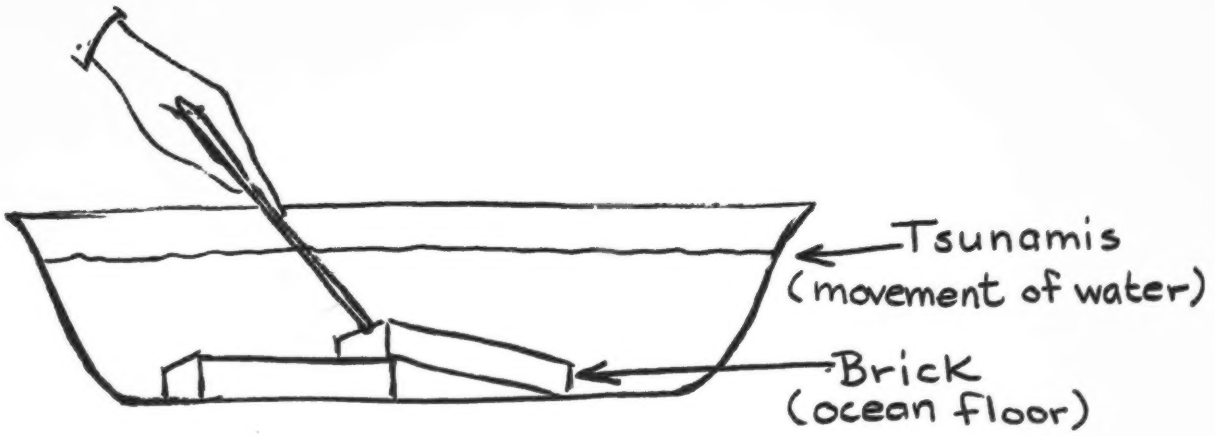
Procedure: Fasten a weight, such as a ball, to the end of a string. Hold the other end of the string in one hand. Rest your elbow on the desk as shown in the diagram. When the ball has stopped moving, ask someone to drop a book on the desk. What happens to the ball?



13. **Leading Question:** What forces effect the water surface of the ocean?

Materials: Large basin, two bricks, water, stick

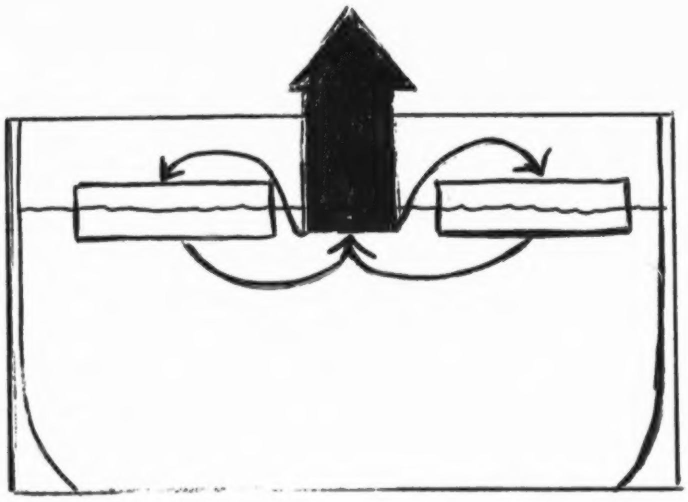
Procedure: Fill basin nearly to the top with bricks positioned one on top of the other in slanted fashion. With stick, push the one brick off of the other. Watch the action of the water surface.



14. **Leading Question:** How is a tsunami formed?

Materials: Two wooden blocks, aquarium or large pan, water

Procedure: Have the children hold two wooden blocks, one in each hand, together at the bottom of an aquarium that is half filled with water. The children should try not to move their arms, but should separate the blocks and move them together again. Have them watch the surface of the water for a miniature tsunami.



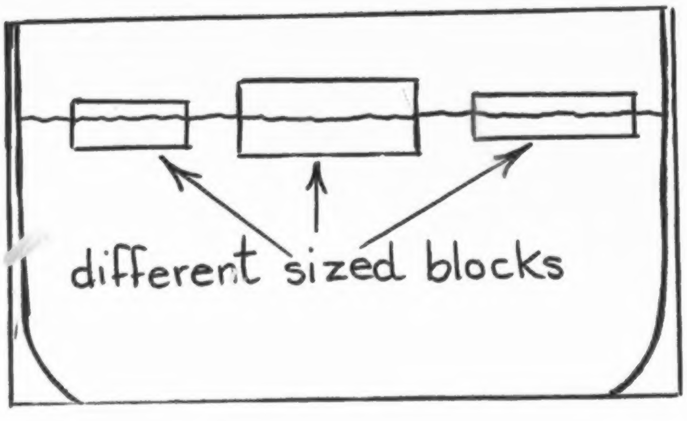
15. **Leading Question:** Why do some materials of the earth's crust float higher than other materials?

Materials: Different sized wood blocks, aquarium, water, weight

Procedure: Place different sized blocks in an aquarium filled with water. Children will notice they sink to different depths, and extend to different heights above the surface of the water. Mark blocks. Place a weight on top of one of the blocks. The block will sink deeper. Of equal importance is the fact that all other blocks rise. Because there is a balance among the blocks, a change in weight of any block affects all other blocks.

The balance in an aquarium can be roughly compared to the balance between materials in the earth's crust. The light materials in the crust float higher than the heavy materials. If some part of the crust is weighted down and sinks under pressure, another part will float higher. This balance in the earth's crust is called isostasy, meaning equal standing.

Isostatic Balance in Aquarium



16. Leading Question: How are volcanoes formed?

Materials: Paper maché or plaster, absorbent cotton, soil, paint

Procedure: Have pupils build a model of a volcano using paper maché or plaster. Label the crater and lava flows. Use absorbent cotton to show the eruption of steam and other gases. Add bits of soil to indicate cinders emptying from the crater. Pupils could paint a body of water around the volcano indicating the formation of an island.

17. Leading Question: What causes the rumbling in a volcano?

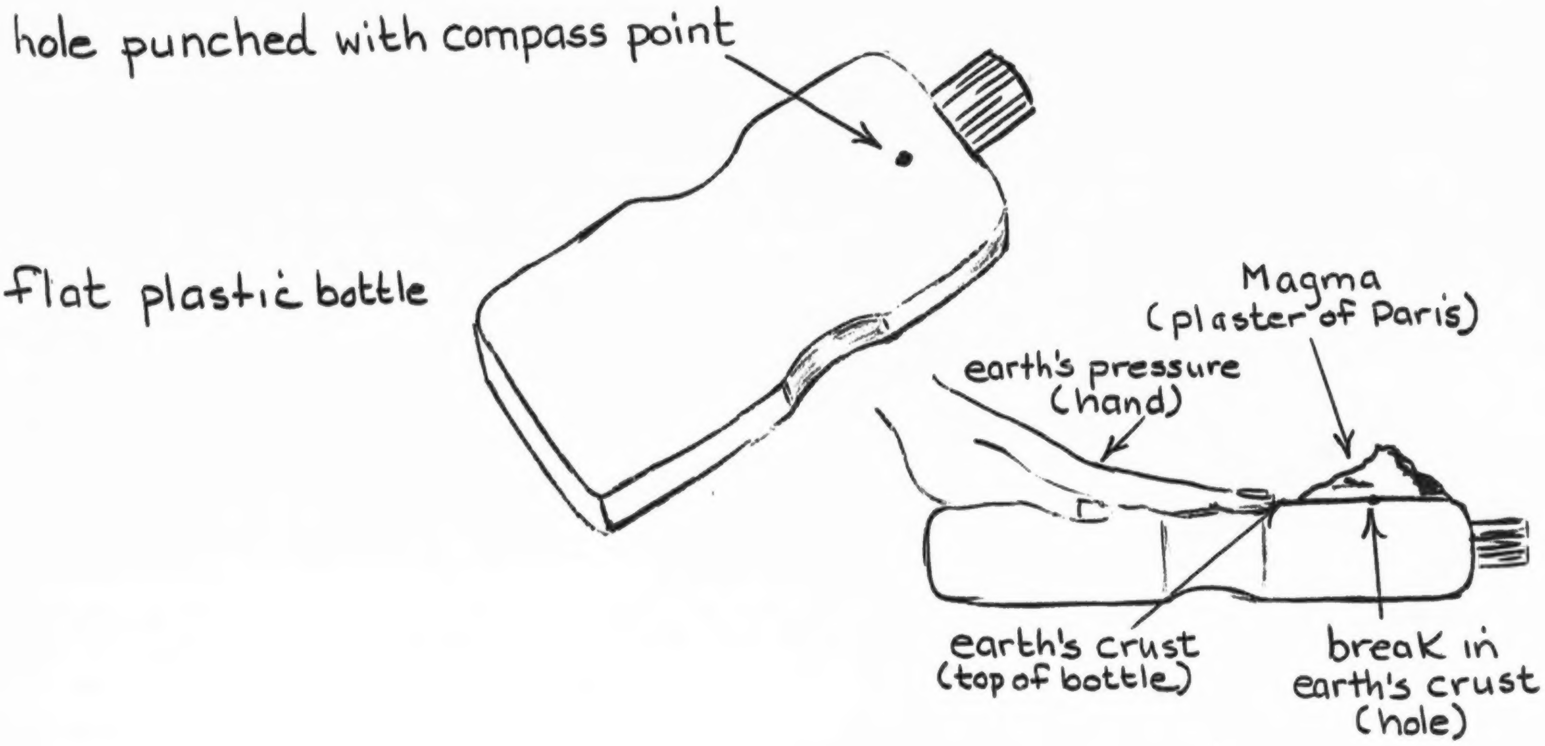
Materials: Unopened bottle of soda pop, pan of water, electric stove

Procedure: Stand a small, unopened, bottle of soda pop in a pan of water. Put the pan on a small electric stove. Stand far enough away so that the top will not hit you if it flies off. What can you see in the soda pop as it is heated? What happens to the bubbles as the pop gets warm? The noise made when a pop bottle cap flies off is made by the movement of the gas in the liquid. The gas expands when heated. The gas is under pressure, and when it is suddenly released, it makes a noise. This is similar to what happens in the volcano. The expanding gas makes the rumbling noise.

18. Leading Question: How do volcanoes build mountains?

Materials: Plaster of Paris, water, flat plastic bottle, large tin can, paper cup, compass

Procedure: Mix plaster of Paris to a thick pancake like batter in the tin can. Pour from tin can into plastic detergent bottle until completely full. Screw cap on tightly. With compass point, punch a small hole near the top of the bottle. Press down firmly on bottle. Plaster of Paris (magma) will pour out and form volcano. Place a paper cup over the "lava" flow to confine it. Allow to harden.


hole punched with compass point
flat plastic bottle
Magma
(plaster of Paris)
earth's pressure
(hand)
earth's crust
(top of bottle)
break in
earth's crust
(hole)

19. **Leading Question:**	How are fold mountains formed?
Materials:	Modeling clay, three small boards
A. Procedure:	Make several flat layers of modeling clay about ½ x 3 x 2". For the flat layers, use different colors of clay. Lay these one on top of the other on a board. Place the other two boards at opposite ends of the board holding the clay. Begin to slowly force these two boards together with your hands. Observe what happens to the clay between the boards. Would you expect this to happen to any similar material when pressure is applied upon it from opposite directions?
B. Procedure:	Geology Models (Central Science Materials Library).
20. **Leading Question:**	How are dome mountains formed?
Materials:	Aquarium, modeling clay, sand, gravel, soil, balloon, hand air pump
Procedure:	Place a balloon attached to a hand pump on the base of aquarium. Place thin layers of clay, sand, soil, and gravel over the base of the aquarium and the balloon. Inflate the balloon slowly. Observe the results of the pressure of the balloon on the layers. What happens to the layers above the enlarging balloon? What will happen if water is poured over the top of the dome? (Examples of dome mountains are the Black Hills of South Dakota.)

21. Leading Question: How are block mountains formed?

A. Materials: Block of soap, knife, paint, brush

Procedure: Unwrap a bar of soap. Cut the bar into two pieces. Paint the edges of the bar to represent the layers of the rock in the earth's surface. Then apply pressure from both ends of the bar toward the center. What happens to the blocks of soap? Why did one block move upward along the cut you made rather than at another point? Do you suppose the face of the block that moved upward can be thought of as a model of a block mountain?

B. Materials: Different colors of modeling clay

Procedure: Pile different colored modeling clay on top of one another to represent different layers of rock. Then cut through the layers at various angles to indicate rock faulting. To show the class the slipping and thrusting action of the faulted sections, raise some of the cut sections and lower others. (Example of block mountains are the Sierra Nevada Mountains.)

22. Leading Question: How does freezing water effect the earth's crust?

Materials: Glass jar, paper bag, freezer

Procedure: Fill a small jar completely with water. Place inside of paper bag and then place in freezing compartment of refrigerator. After a few hours, possibly a day, remove and examine carefully. Allow ice to melt; bottle should be broken.

23. Leading Question: How are rocks changed to soil?

Materials: Various rocks, diluted hydrochloric acid

Procedure: Pour diluted hydrochloric acid on various rocks. Observe chemical reaction. Discuss results in relationship to unequal wearing away of earth's surface.

24. Leading Question: How does freezing water widen cracks in rocks?

Materials: Plaster of Paris

Procedure: From plaster of Paris, make a block with a crack in it. Pour in water and freeze. Is the crack wider?

25. Leading Question: How do growing plants change the earth's surface?

Materials: Rocks with growing lichens

Procedure: Examine rocks, then scrape some of the lichens off with a knife on to a piece of white paper. Notice the bits of rock that flake off with the lichens.

26. Leading Question: Do rocks absorb water?

Materials: Rocks, water

Procedure: Place pieces of rocks in pan of water. Soak for about twenty minutes, remove them and attempt to wipe the rock dry. When the water in a rock freezes the rocks may break apart and thus are weathered.

27. Leading Question: What is the effect of chemical weathering?

Materials: Pieces of iron

Procedure: Place one piece of iron in a dry place, another in a damp place. Observe from day to day which piece of iron rusts first.

28. Leading Question: How does freezing water help the leveling process?

Materials: Glass jar, water, screw cap, plastic bag

Procedure: Pour water into the bottle until it is completely filled. Screw the cap on tightly. Set the bottle in a place where the water will freeze. What happens to the bottle when the water freezes?

Weathering breaks bedrock into smaller and smaller pieces. When rocks containing the mineral quartz, or silicon dioxide are broken up, the quartz is usually left as sand. Most other minerals are broken into much finer particles, forming clay.

Note to teacher: Place the bottle in a plastic bag before freezing.

29. Leading Question: How does a grass cover affect the amount of soil erosion?

Materials: Two trays and screen

Procedure: Fasten a screen window to an open tray. Fill both trays, one with soil and the other with sod or growing grass. Place the other end of each tray on a brick or box so that both trays slope downward at the same angle. Sprinkle an equal amount of water upon the upper part of each tray. Measure the amount of water in each pan. From which tray did more water run off? From which tray was more soil lost?

30. Leading Question: How do earthworms and other animals change our soil?

Materials: Soil, box, paper

Procedure: Dig a spadeful of soil and place it in a box. Spread some clean paper on a table or on the floor. Have children separate the components of soil, placing the rock particles in one pile, humus in another pile, twigs, stems, roots, and leaves in a third pile and so on. Place any animals, such as insects or worms, into separate bottles. Discuss the importance of these components.

Note to teacher: The earthworm helps renew the soil, it loosens the soil. It eats materials in the soil and breaks them down. Other animals besides earthworms are moles, gophers, burrowing beetles and micro-organisms.

31. Leading Question: How are glaciers formed?

Materials: Sand, glass plate, shaving cream

Procedure: Release some shaving cream from an aerosol can onto a glass plate. Sprinkle fine grains of sand onto the upper surface of the shaving cream. Wait several minutes. Then add another layer of shaving cream and another layer of sand. Add a top layer of shaving cream to the final layer of sand. Cut across the mass of shaving cream in different areas. What do you observe? Does the cross section serve as a model of a glacier? Does it suggest the layers of ice within a glacier?

32. Leading Question: Was the area in which we live covered by glaciers?

Procedure: Find out if the area in which you live was covered by glaciers. Locate evidences of glacial deposits such as fields covered with stones, huge boulders in unusual places, and scratched rocks. (Refer to Grade Four Northampton County Field Trip-Appendix.)

33. Leading Question: How does a glacier change the physical nature of a valley?

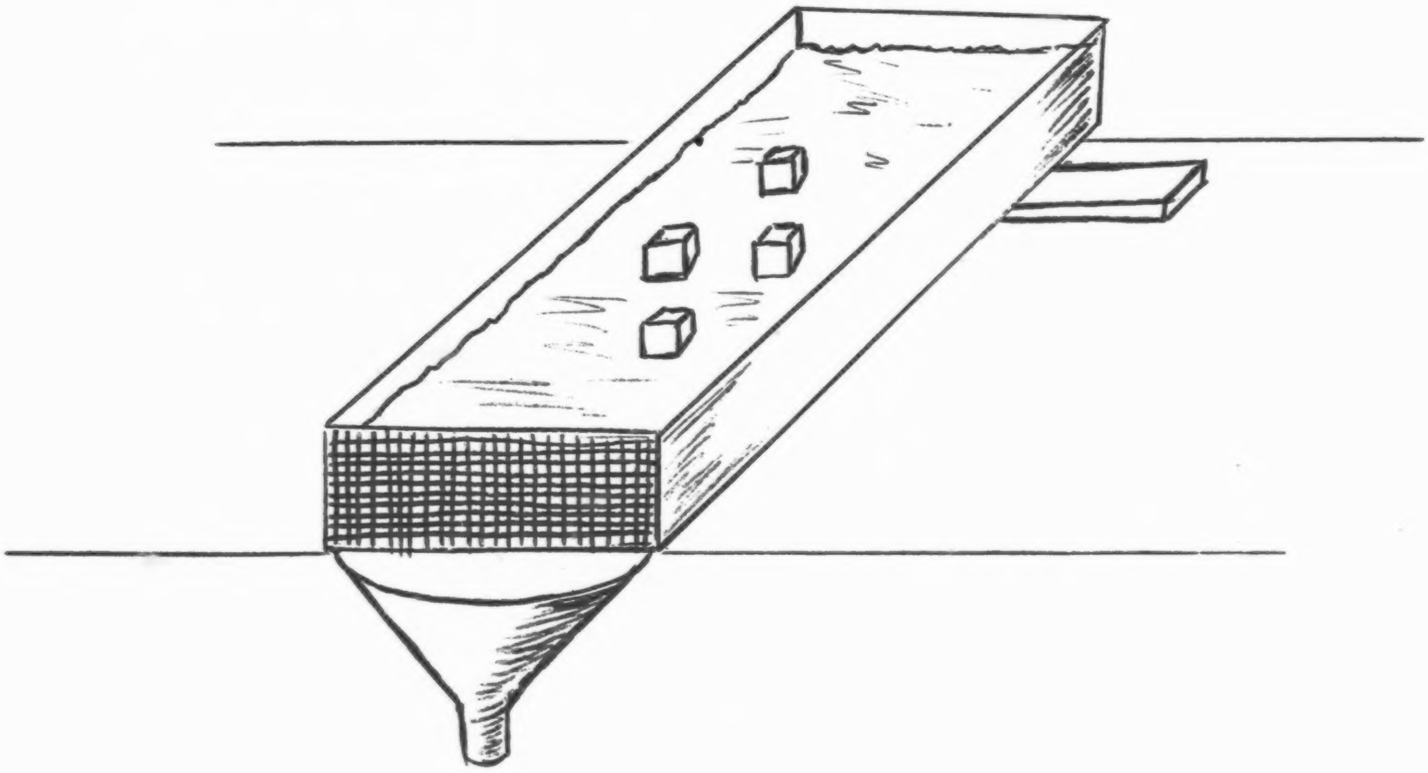
Materials: Sand, plastic tray, ice cube

Procedure: Rub an ice cube over the surface of a plastic tray. Then observe the surface. Is there a change? Now place some sand under the ice cube and continue to rub. Then examine the surface. Does the change suggest the action of a glacier upon the surface of the earth?

34. Leading Question: How does ice change the earth's surface?

Materials: Tray, screen, funnel,

Procedure: Set the tray in a sloping position and fill it with soil. Put some ice or ice cubes at the top of the incline and notice what happens as they melt. If any of the ice cubes slide down the soil, pick one up and notice that it carried soil with it. Rub one of the cubes over the soil and see how it picks up soil.



35. Leading Question: What happens when a glacier moves and then melts?

Materials: Metal tray, sand and pebbles mixture, water

Procedure: Place a mixture of sand and pebbles on the bottom of a tray, cover with water and place in freezer of refrigerator until water freezes to ice. Repeat several times until tray is filled with ice and sand and pebbles mixed in with ice.

Find a flat, soft rock such as limestone or sandstone. You may wish to use a brick, or make a soft rock by drying a block of wet clay.

Take the ice out of the tray and place the side with the sand and pebbles on the soft rock. Push the ice as hard as you can across the soft rock. Did you make scratches in the rock? What is the direction of the scratches?

Place the ice in a box and allow the ice to melt. What is left in the box? Are the deposits left in layers or are the small particles of sand and layer pebbles all mixed together? Have you ever seen soil that looks like these deposits?

36. Leading Question: How are kettle holes (deep pits left by melting glaciers) formed?

Materials: Tray, ice cubes, sand

Procedure: Bury two or three ice cubes in tray with sand. When the ice melts the sand above the ice sinks or caves in forming depressions.

Pour water into depression (the forming of lakes).

37. Leading Question: Why is the biggest portion of an iceberg beneath the water line?

Materials: Water, ice cube, graduated cylinder

Procedure: Add 500 ml of water to a large graduated cylinder. Then place an ice cube in the water. At what level do you now find the water? At what level do you find the water after the ice cube melts? Does the difference between the three levels of water tell you anything about the volume of ice in relation to the volume of liquid water?

38. Leading Question: How does flowing water change the surface of the earth?

Materials: Tray, squeeze bottle, soil mixture

Procedure: Fill tray with mixture of soil and pebbles. Direct a stream of water over tray, using a squeeze bottle.

After a stream bed has been formed, examine the result. Repeat. Examine. By varying the force of water, different stream beds can be formed.

Place a small rock in the path of the water. Note the results. Also use different soil mixtures.

This activity could be used to illustrate erosion.

39. **Leading Question:** Where is our community's water supply?

Materials: Field trip and report

Procedure: Prepare a report on your community's water supply. Arrange a field trip to the Wild Creek Reservoir so that the class can see:

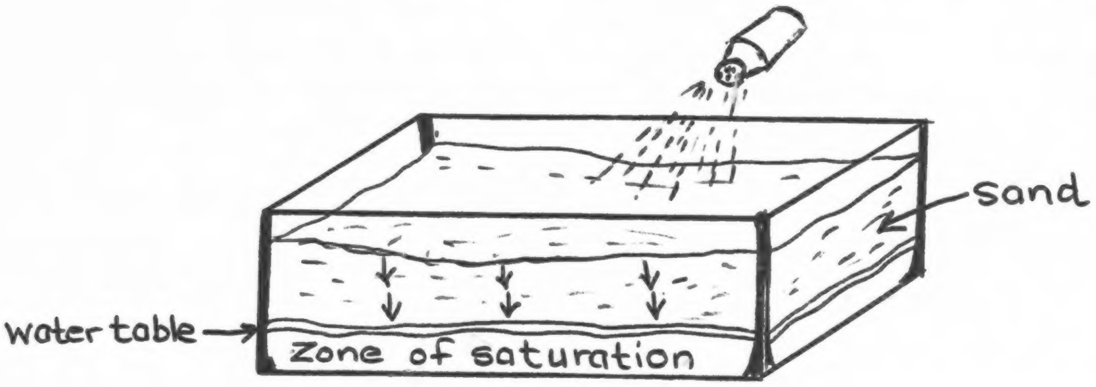
1. Where the water comes from.
2. How the water is treated chemically to make it clear and pure.
3. What is being done to prevent water shortage problems.

40. **Leading Question:** How is a water table formed?

Materials: Aquarium tank, sand, water

Procedure: Fill a small aquarium tank half full with sand. On one end of the tank pile up more sand than at the other end. Sprinkle water on the surface of the sand, adding more water until the sand at the bottom of the tank appears saturated with water. The top region of the sand that is saturated with water is called the water table.

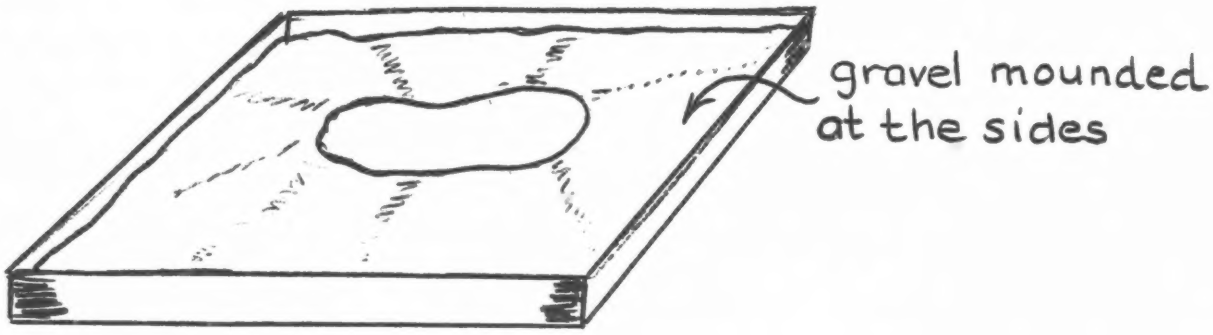
Note to teacher: The water table is the level to which the underground reservoirs are filled with water, and is the depth to which a well must be dug to reach water. The water below the water table is the principal source of supply for wells and is designated as free water. The zone of saturation generally develops over impervious matter or rock and includes water pulled down through the soil by gravity.



41. Leading Question: What land formations contain surface water before it runs out to the ocean?

Materials: Metal tray, coarse and fine sand (aquarium gravel)

Procedure: Fill a metal tray with gravel on four sides and create a depression in the center to almost the bottom of the tray and at least eight inches in diameter. Pour water into the corners slowly until water fills "lake".

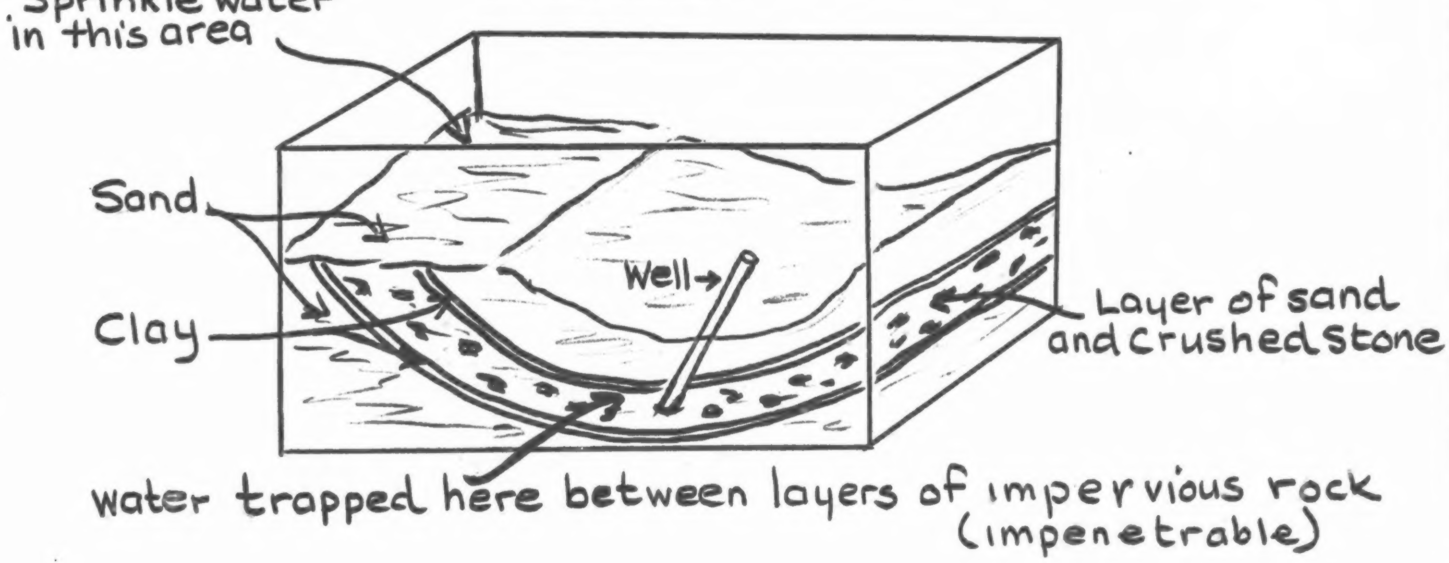


42. Leading Question: What methods are used to tap ground water?

Materials: Aquarium tank, modeling clay, three quarts of coarse sand, one quart of fine crushed stone, and glass tube three inches long.

Procedure: Place two sheets of clay against the glass sides of the aquarium so that it forms a watertight seal. Add sand and gravel as shown in diagram. Insert glass tube to simulate well. Sprinkle water in area directed and water will come through the tube. (Or artesian well.)

Note to teacher: Vast quantities of water are stored in places where water is trapped in porous rock particularly between two layers of impervious rock. Water entered the trap at some elevated place through porous matter, and seeped down the slope to the lowest point of the basin.

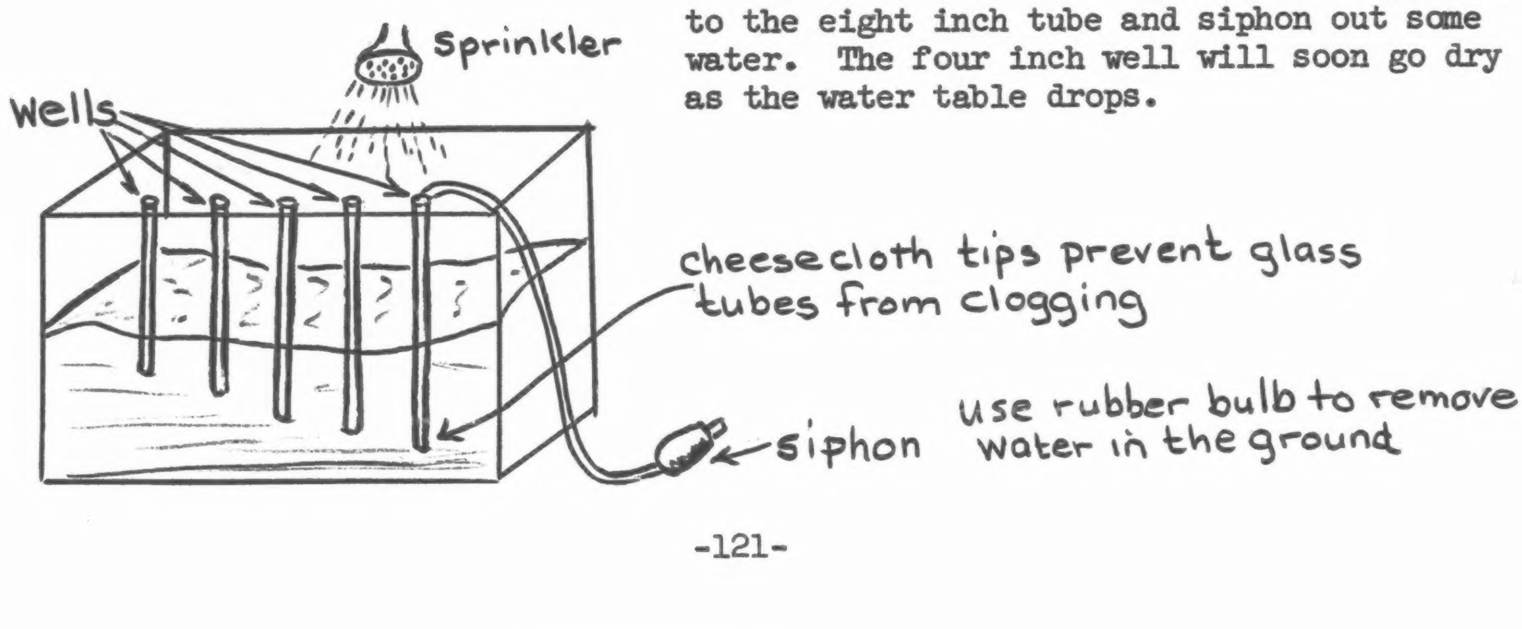

Sprinkle water in this area
Sand
Well
Clay
Layer of sand and crushed stone
water trapped here between layers of impervious rock (impenetrable)

43. Leading Question: What methods are used to tap ground water?

Materials: Aquarium, scotch tape (one inch wide), siphon, sand, five pieces of glass tubing (8", 7", 6", 5", 4"), cheesecloth, rubber band

Procedure: After you have the desired lengths of glass tubing, cover the bottom of the tube with cheesecloth securing it with a rubber band. Fasten the glass tubes to side of aquarium with scotch tape lengthwise along each tube. Fasten the longest tube (8") one inch from the bottom of the tank. The remaining tubes should all be the same level at the top, but the bottoms should be an inch higher than the next. Pour sand into the tank so that the bottom of the shortest tube is at least two inches below the surface of the sand.

Sprinkle water into the tank, water will begin to show up in the glass tubes. Sprinkle enough water so that there is about two inches in the four inch tube. Insert the siphon into the eight inch tube and siphon out some water. The four inch well will soon go dry as the water table drops.


Sprinkler
Wells
cheesecloth tips prevent glass tubes from clogging
siphon
use rubber bulb to remove water in the ground

CURRENT PROBLEMS

44. Leading Question: What methods are used in our city to treat sewage?

Materials: Class trip

Procedure: Arrange a class trip to the city sewage disposal plant to see what methods are used to treat sewage. Before making the trip, have students report on some of the methods used to treat sewage.

45. Leading Question: How is burning of trash without sufficient oxygen polluting our air?

Materials: Few chips of wood, pie tin, match, damp paper towel

Procedure: Place a few chips of wood in a pie tin and set them on fire. Throw a damp paper towel over the burning chips. The fire will produce much smoke because the burning material is not receiving enough oxygen for complete burning.

Let children compare that much smoke from smokestacks and chimneys indicates that the fuels in the furnaces are not being burned with a sufficient supply of oxygen.

46. Leading Question: Investigate the findings of what industry in our area and automobile manufacturers are doing to correct air pollution problems.

Procedure:

a. Have one or more advanced students write to a major automobile manufacturer requesting information about automobile exhaust filters. Have him explain to the class how automobile exhaust filters operate.

b. Have one or more pupils write to the large industries in our area (Bethlehem Steel, Lehigh Portland Cement, etc.) to try to find out what smoke abatement measures they use.

c. Invite a member of the county health department to talk to the class about the dangers of air pollution and what local laws are designed to control pollution.

47. Leading Question: How does the water cycle help keep water clean?

Materials: Saucer, muddy water

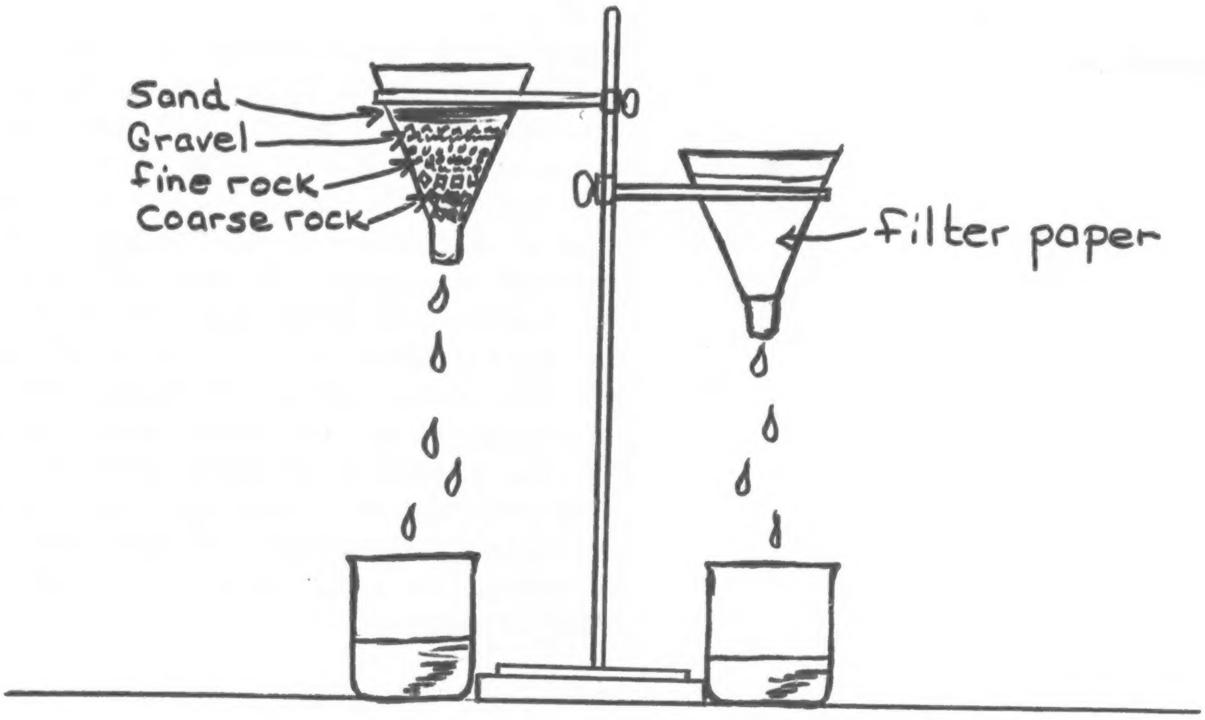
Procedure: Place a saucer of muddy water on an open shelf and allow the water to evaporate. Have students observe the residue that remains.

48. Leading Question: How is sediment removed from surface water?

Materials: Ring stand, two funnels, beakers, filter paper, small amounts of sand, gravel, fine rock, coarse rock, water with sediment.

Procedure: Set up apparatus as shown in drawing. In one funnel fill with layers of rock, gravel, sand, the other with filter paper. Mix muddy water and pour into both funnels. Observe the water which drips into the beakers. If the water that drips from the sand and gravel funnel is still muddy, plug the neck with absorbent cotton.

Note that filtration alone does not make water safe to drink, but is only used to filter out undissolved particles.



49. Leading Question: Why are mineral resources of the lithosphere non-renewable?

Materials: Iron, copper, lead, zinc or silver

Procedure: Assign several students in the class to bring a metal object such as iron, copper, lead, zinc or silver and ask each to find out where the metal occurs as an ore, how it is mined and how it is refined. Lead discussion so that children will realize that once metals are taken from the earth, for all practical purposes, they are gone forever.

50. Leading Question: What substitutes are being used to replace some household materials once made of iron and steel?

Materials: Aluminum, magnesium, alloys, plastics

Procedure: Children can bring to the classroom some household materials made of aluminum, magnesium and certain plastics.

51. Leading Question: Why are some metals coated with another metal?

Materials: Dry cell, wire, old jelly glass, clean nail, copper sulfate ($Cu\ SO_4$)

Procedure: Dissolve a teaspoonful of copper sulfate in enough water to fill the jelly glass three-fourths full. Scrape off the insulation from both ends of a six inch piece of wire. Fasten one end of the wire to the nail and the other end of the wire to the negative binding post of the dry cell. Scrape off about six inches of insulation from one end of a longer piece of wire. Make a tight coil of the bare part of the wire. After scraping off a little insulation from the other end, fasten the wire to the positive binding post of the dry cell. Now put the nail and the coil into the glass in which the copper sulfate was dissolved. Be sure the nail does not touch the coiled copper wire.

The nail becomes the cathode and the coil of copper becomes the anode. You soon will have a copper nail, this process is called electroplating. Electroplating often is used to plate objects made of cheap metal with gold or silver.

Note to teacher: Copper sulfate is poisonous. Be very careful how you handle it.

DIGGERS TO DIVERS

TEXTBOOK INDICES

3 **PUBLISHER:** Allyn and Bacon **SERIES:** Exploring Science Series **EDITION:** 1955-1960 1964-1965

Diggers to Divers	Related Pages in Textbooks K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil				145-158	60-63 165-200			
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil						49-65		
Landforms								
Paleontology						66-70		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								202
Physical Oceanography								
Biological Oceanography							293-314	
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water						313-336		(1965) 378-391
Current Problems								
Special Notes:								

PUBLISHER: **American Book Co.** SERIES: **ABC Science Series** EDITION: **1961-1964**

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil		31-56	65-96					
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil			31-65					
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					39-70			
Landforms						1-48		
Paleontology					71-120	70		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography						4,5		
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography						104-107, 112-119,123, 132-135,150-151		
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						1-48		
Glaciers						25-29		
Streams - water						7-20		
Current Problems								
Special Notes:								

PUBLISHER: American Book Company SERIES: Thinking Ahead in Science EDITION: 1965

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock					35-39			
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					1-48			
Landforms					1-48			
Paleontology					49-96			
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean					24	2,3	178-202	
Geological Oceanography					36	29,30	203-206	
Chemical Oceanography					122		213-218	
Physical Oceanography						16,17	207-212	
Biological Oceanography					60,70,71	151	219-232	
Uses of the Ocean							233-236	
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: Bobbs Merrill

SERIES: The World of Science Series EDITION: 1966

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				75-84	45-96	226-230		
Landforms				85-119				
Paleontology					161-194			
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean						218-225		
6 THE CHANGING EARTH								
Geologic Changes						211-271		
Glaciers						227-228		
Streams - water								
Current Problems						253-271		
Special Notes:								

PUBLISHER: **D.C. Heath and Company** **SERIES: Heath Elementary Science** **EDITION:** **1959-1961**

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US		10	34-45					
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				23-41 57-74				
Properties of Soil				23-41				
Sedimentary Rock				138-151 62-74				
Uses of Rocks and Minerals			42-45 56-62	57-59 64-73 144-146				
4 PETROLOGY								
Rocks, Minerals, and Soil				22-41	191-193			
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						15-20 (map skills)		
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography						10,11,13-15		
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: **D.C. Heath and Company** SERIES: **Heath Science Series** EDITION: 1965

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				**211-229**				
Properties of Soil			**187-199**					
Sedimentary Rock				**231-249**				
Uses of Rocks and Minerals			**66-91**					
4 PETROLOGY								
Rocks, Minerals, and Soil				**231-249**				
Landforms				**211-229**	**289-290**			
Paleontology				**231-249**				
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY				67-92				
Exploring the Ocean							328,331	
Geological Oceanography							328,329	
Chemical Oceanography							331,332	
Physical Oceanography					291-297	46-48	338,339, 340-341	
Biological Oceanography							333-337	
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						255-291		
Glaciers								
Streams - water						293-313		
Current Problems						315-331		
Special Notes:								

PUBLISHER: **Ginn and Company** SERIES: **Discovering Science** EDITION: **1958**

Diggers to Divers	Related Pages in Textbooks K	1	2	3	4	5	6	7
K ROCKS AROUND US		56-60						
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT		82-87						
Formation of Rock					79-83 218-225 231-232			
Properties of Soil								
Sedimentary Rock					226			
Uses of Rocks and Minerals					211-217 233-235			
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: Ginn and Company SERIES: Science for You EDITION: 1965

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil		98-103						
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms				130-153		50-57		
Paleontology						188-197		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography						74-81		
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						33-61		
Glaciers								
Streams - water			134-149			257-275		
Current Problems								

Special Notes:

PUBLISHER: Harcourt, Brace and World   SERIES: Concepts in Science   EDITION: 1966

Diggers to Divers	Related Pages in Textbooks K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				159-181		2-49		
Landforms					218-253	2-49		
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						11		
Geological Oceanography						12-16 336		
Chemical Oceanography						35,78, 334		
Physical Oceanography					80			
Biological Oceanography								
Uses of the Ocean						81		
6 THE CHANGING EARTH								
Geologic Changes						Workbook 5-26 5-49		
Glaciers						5-15		
Streams - water								
Current Problems								

Special Notes:

PUBLISHER: Harcourt, Brace and World SERIES: Classroom Laboratory EDITION: 1966 (Available from Central Science Material Library

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil			63 & 64					
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				82,85	79	35,37,40 44,45		
Landforms						34		
Paleontology			100			119		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								

Special Notes:

PUBLISHER: **Harper and Row** SERIES: **Today's Basic Science** EDITION: **1963-1965**

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil			128-155	54-61				
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil			128-155		93-123			
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					93-110	181-191		
Landforms					110-119	181-191		
Paleontology					119-123	192-200		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						202-216		348-351
Geological Oceanography								340-345
Chemical Oceanography						216-219		
Physical Oceanography					166-170			345-348
Biological Oceanography					171-182	220-232		
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						181-200	141-176	
Glaciers								
Streams - water								
Current Problems							159-176	
Special Notes:								

PUBLISHER: **Harper and Row** SERIES: **Today's Basic Science** EDITION: **1967**

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil			146-176		107-139			
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					92-110	199-209		
Landforms					111-121	199-209		
Paleontology					134-136	210-220		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						222-236		
Geological Oceanography								
Chemical Oceanography						236-239		
Physical Oceanography					186-190			
Biological Oceanography					191-202	240-252		
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes							153-189	
Glaciers								
Streams - water								
Current Problems							168-189	
Special Notes:								

PUBLISHER: Holt, Rinehart and Winston, Inc. SERIES: Science/A Modern Approach EDITION: 1963 - 1967

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil	Chart 14							
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				6-70	94-147			
Properties of Soil								
Sedimentary Rock				78-84				
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil	Chart 14			60-101	94-147			
Landforms	Chart 6				94-147			
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						110-112 113-120,122 123-128		203-210
Geological Oceanography								210-221
Chemical Oceanography						121		210-221
Physical Oceanography								210-221
Biological Oceanography								210-221
Uses of the Ocean								218-219
6 THE CHANGING EARTH								
Geologic Changes	Chart 6							225-250
Glaciers								245-247
Streams - water								119-140
Current Problems								251-269
Special Notes:								

PUBLISHER: Laidlow **SERIES:** Science Series **EDITION:** 1966

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock					104-105 111-112			
Properties of Soil					122-124			
Sedimentary Rock					104,112			
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					104-112			
Landforms								
Paleontology						100-110		
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean							79-80,82, 85,87-89	
Geological Oceanography								
Chemical Oceanography							83-89	
Physical Oceanography							90-93	
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: Lyons and Carnahan

SERIES: Develomental Science Series EDITION: 1958-1964

Diggers to Divers	Related Pages in Textbooks K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				154-167				
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil					182-183	210-237		
Landforms						210-237		
Paleontology				56-77				
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography						239-257		
Uses of the Ocean							259-260	
6 THE CHANGING EARTH								
Geologic Changes						210-237		
Glaciers								
Streams - water								
Current Problems							240-269	
Special Notes:								

PUBLISHER: **Macmillan Company** SERIES: **Science Life** EDITION: **1959**

	Related Pages in Textbooks							
	K	1	2	3	4	5	6	7
Diggers to Divers								
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean							267-270	
Geological Oceanography								
Chemical Oceanography							271-275	
Physical Oceanography								
Biological Oceanography							275-277, 279	
Uses of the Ocean							277-278 280-284	
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: Macmillan Company SERIES: The Macmillan Science Series EDITION: 1966

Diggers to Divers	Related Pages in Textbooks K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				71-73				
Properties of Soil				62-70				
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				72				
Landforms				69,120				
Paleontology				69				
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean						311		
Geological Oceanography						335-338		
Chemical Oceanography						333-334		
Physical Oceanography						330-338		
Biological Oceanography						339-342 345-347		
Uses of the Ocean						342-343, 348-349		
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								320-32
Special Notes:								

PUBLISHER: Scott, Foresman

SERIES: Curriculum Foundation Series

EDITION: 1961-1964 - 1965

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock				86-94				
Properties of Soil				94-104	122-128			
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				86-104	118-128			
Landforms				86-104	102-117			
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								266-267 284-285 340,366-367
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography							140	
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						99-122		
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: Silver Burdett Company

SERIES: The Silver Burdett Science Program EDITION: 1965

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil		36						
3 SAND, SOIL, AND SEDIMENT		54						
Formation of Rock				30-37 40-45				
Properties of Soil				44-50				
Sedimentary Rock				38-43				
Uses of Rocks and Minerals				92 102-107				
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean					51			
Geological Oceanography								
Chemical Oceanography					37			
Physical Oceanography								
Biological Oceanography					72-75			
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water			69-85					
Current Problems								
Special Notes:								

PUBLISHER: **The L. W. Singer Company** SERIES: **Singer Science Series** EDITION: **1959-1964**

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock			186-187					
Properties of Soil				17-26 41-44 50-56				
Sedimentary Rock				41-49				
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil				50-56	59-81			
Landforms				45-49				
Paleontology				57-59	261-272			
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography							218-228	
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes						51-92	185-209	
Glaciers								
Streams - water							185-194	
Current Problems							162-184	
Special Notes:								

PUBLISHER: Singer Random House

SERIES: Science Through Discovery EDITION: 1967

Diggers to Divers	Related Pages in Textbooks							
	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil			138-155					
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil		72-83						
Landforms								
Paleontology			156-165					
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: SERIES: EDITION:

	Related Pages in Textbooks							
Diggers to Divers	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER SERIES: EDITION:

Diggers to Divers	Related Pages in Textbooks							
	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
Chemical Oceanography								
Physical Oceanography								
Biological Oceanography								
Uses of the Ocean								
6 THE CHANGING EARTH								
Geologic Changes								
Glaciers								
Streams - water								
Current Problems								
Special Notes:								

PUBLISHER: **SERIES:** **EDITION:**

Diggers to Divers	Related Pages in Textbooks							
	K	1	2	3	4	5	6	7
K ROCKS AROUND US								
Rocks and Soil								
3 SAND, SOIL, AND SEDIMENT								
Formation of Rock								
Properties of Soil								
Sedimentary Rock								
Uses of Rocks and Minerals								
4 PETROLOGY								
Rocks, Minerals, and Soil								
Landforms								
Paleontology								
County and State Geology								

Diggers to Divers	K	1	2	3	4	5	6	7
5 OCEANOGRAPHY								
Exploring the Ocean								
Geological Oceanography								
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DIGGERS TO DIVERS

APPENDIX

GEOLOGICAL HISTORY OF NORTHAMPTON COUNTY

Geologists have dated the oldest rocks on the earth at four and one half billion years. The oldest known rocks in Northampton County are approximately one billion years old. These sedimentary rocks are limestones and are found on the south side of Chestnut Hill from the Delaware River across the Bushkill Creek to the north of Easton as well as in the peaks of South Mountain. The sediments of the sea were uplifted as the earth's crust began to shrink, crack, and crumple. Molten rock intruded these sediments and formed the main portions of Chestnut Hill and South Mountain. The molten rock has given these limestones their striped, sparkling appearance.

Erosion on the uplifted land was constant and over many millions of years, much land was worn away. Then the area gradually sank beneath a southeasterly advancing inland sea. The shallow inland sea varied in size and shape due to the earth's crustal movement. Geologists believe there was a large continental land mass called "Appalachia" which lay to the east of the present Atlantic shore line. The distance from Northampton County to this land mass varied, from a few miles to more than a hundred miles.

Sediments were deposited on the gradually sinking bottom of the inland sea. These sediments were eroded from "Appalachia". The very fine sediments became limestone, and the rock floor of much of the lower part of the County on the south side of the Lehigh River and Saucon Valley. Calcareous algae, which were extremely simple forms of life, were abundant. Fossils of these sea-dwelling algae, called Cryptoza, appear in limestones as small lumps in rocks. The water covering the County was not very deep. The indications of shallow waters are colites, mud cracks, and ripple marks.

About 450 million years ago, shell fish were abundant and the first forms of fish began to develop. The sea was fairly clear and fine sediments were deposited. Again the County was uplifted, and again the inland sea covered the area. The lime sediments which were deposited became the valuable limestone used in the making of cement. Apparently this was a favorable time for life, as fossils from this period are more abundant, but are mostly fragmented as their skeletons have been broken by wave action.

Deposition of sediments was made for approximately 200 million years. These sediments which had accumulated to a thickness of up to 10,000 feet were folded and faulted as a result of compression and uplifting. Apparently the shales and slates of the slate belt were produced during this period. A long period of erosion followed the Taconic Revolution when the entire County was above water. Once again the region sank below the surface of the huge inland sea. The land mass to the southeast had apparently developed steep slopes. From this land mass, coarse pebbles and coarse sand were swept into the inland sea. Strong currents deposited this material at the northern end of the county. These conglomerates and sandstones are found in the Kittatinny Mountains. The Appalachian Revolution occurred as renewed compression from the southeast caused more folding, faulting, and uplifting of thousands of feet of rock.

Some geologists are of the opinion that Pinetop Hill and Camel's Hump were created at this time. They believe this occurred when large masses of rocks were broken off from South Mountain, slid north across the valley, and stopped at their present location. There is much evidence to support this theory.

About 200 million years ago, the southern boundary of the County was covered by the ancient sea. The red shales and conglomerates found at Flint Hill are the result of depositions made at that time. These are part of a series of deposits formed in low-lying land valleys from Massachusetts to North Carolina.

The ice age of the County occurred from about one million years ago until the glacier retreated ten thousand years ago. Geologists know that there were at least four advances of the ice sheet, but they believe that only three reached Northampton County. Possibly the first advance deposited the gravels and cobbles on the tops of hills in Saucon and Williams townships. The second probably left a drift of gravel and sand over the Saucon Valley and the eastern part of Bethlehem. The latest scratched surface rocks and deposited loose rock, sand, and soil along the west side of upper Martin's Creek through the Bangor-Pen Argyl-Ackermansville area. There are many low, irregular hills composed entirely of glacial debris which reach a heighth of up to 70 feet. Some of these deposits are presently being worked as strip mining operations for building materials.

The topography of the area has resulted from deposition of materials, compression with subsequent uplifting, and erosion. The hills and valleys have been created through streams, floods, and decomposition. The resistant sandstones of the Kittatiny Mountains have been least affected and are now the highest portion of the County. The limestones which are softer and more soluable rocks are the valley parts of the County. The destructive and creative forces of erosion and deposition will continue to modify the topography of Northampton County.

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NORTHAMPTON COUNTY

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Source: Northampton County, Pennsylvania
Geology and Geography

NORTHAMPTON COUNTY FIELD TRIP WITH EMPHASIS ON GEOLOGICAL FEATURES.

TIME - Approximately 4½ hours including lunch.

EASTON AVENUE (OLD ROUTE 22) To Easton --- (William Penn Highway)

Believed to have been the Indian Path from Bethlehem to Easton. Made wider and more passable through usage by horses and wagons. First concrete (cement) highway in Pennsylvania opened by Gov. Brumbough.

This is the limestone area.

Mountains to the right - These mountains are across the Lehigh River, are locally called South Mountain and Lehigh Mountain. They are a part of the Reading Prong of the New England Uplands.

Notre Dame High School to the left.

Farmersville School on the right.

Notice the rolling hills and valleys. The farmland is very fertile.

On the left, notice the Blue or Kittatinny Mountains after passing Food Basket. Wind Gap can also be seen on the left.

Easton High School on the left.

Dixie Cup Plant -- ahead on the left.
First hot drink cups were made here.
Ice cream containers known as "dixie cups" first produced here.
Cup on top is capable of holding 50,000 gallons of water.

Wilson Borough - The Borough and the schools on left were named in honor of President Woodrow Wilson.

Butler Street - elevated --- Lehigh River is below on the right.

In Easton - Bear left on Walnut Avenue - Turn right on Ferry Street.

Easton was named by Thomas Penn in 1751 in honor of his father-in-law's estate, Easton Neston in Northamptonshire, England. Penn descendents owned land here until 1931.

County Courthouse - on right - was built in 1860-61. People were divided as to whether or not the new courthouse should be put on this high elevation. All county business is carried on here. The Northampton County "Liberty Bell" hangs in the belfry of the County court house. This bell was rung at the time of the reading of the Declaration of Independence in Easton on July 8, 1776 in the first courthouse on the square in Easton.

Monument on the front of the courthouse lawn is a memorial to the "Martyrs of the Maine" and to the Spanish War Veterans - 1892. The projectile on top is from the "Maine" - the U. S. Warship blown up in Havana Harbor, Cuba.

The County jailhouse is to the rear of the courthouse. The Juvenile Home and the Easton City Hall are on the right.

Easton Public Library (Depending on the bus route, this may come up later, after passing Center Square.)

City flag adopted March 6, 1908.

Mt. Jefferson - elevation 286 feet - is to the rear of the library. Andrew Carnegie donated $50,000 for the library building which was dedicated in 1903. William Parsons is buried here. His tomb is to the right of the original library building, and between the two buildings (the original and the new one). He was an Englishman who was employed by the sons of William Penn to lay out the plans for the county seat, Easton. It took him just ten days to complete the plans. One of the most valuable historical collections in Pennsylvania is housed here. The "First Stars and Stripes", one of the first United States flags is on display in the library.

Straight down Ferry Street to Fourth - Turn right at Fourth (Stop).

Northampton County Historical and Genealogical Society - on right corner.

Iron Grape and Ivy Fence on right beside Northampton County Historical and Genealogical Society House.

The Parsons-Taylor House now called the George Taylor House - diagonally across the street. The house was built for William Parsons in 1757. Was occupied by George Taylor, a signer of the Declaration of Independence and a friend of Benjamin Franklin. George Washington was entertained in the courtyard beside the house, now owned, restored, and maintained as a Historical Memorial by the Easton chapter of the DAR (Daughters of the American Revolution).

Slate pavements are on this portion of S. Fourth Street

St. John's Lutheran Church - across street - (Belfry 1740).

Parking Lot beside Church - formerly site of Taylor School.

Turn left at first traffic light (Lehigh Street).

Old railroad station -- look to the right.

Turn left on Third Street -- (traffic light).

Mount Washington - name given to high limestone bluff on south side of Lehigh River at its junction with the Delaware River. Named for George Washington. Note rock layers on left side - uplifted by forces below the earth's surface.

Marker - Samuel Phillippi -- on right -- site of gunsmith ship in 1846.
Mr. Phillippi made violins and the first split bamboo fishing rods.

Halfway around square -- turn right toward Farr's.
Center Square - site of first court house. Annual rent of one red rose a year is still paid.
Farmer's Market - open air market several days a week during warm weather.
Pillory - taken down during the winter to preserve it.
Monument in Center Square - erected in honor of the Union soldiers and sailors (1861-1865) who fought in the Civil War.

Bixler's - first jewelry store in America - founded in 1785.

Around the Center Square - right turn to 611 - Toward Stroudsburg.
First Reformed Church - Congregation formed in 1746. Church was built in 1776, restored in 1952. Easton's oldest public building. Used as a hospital during Revolutionary War.
Easton's first church school house - A log building erected in 1755. Served as a church and school. The stone building - built in 1778 was used as a school - now is a Church Office and Pastor's Study.

Lafayette College - on hill straight ahead.
Founded in 1824 by a group of men from Easton.
First college in U. S. which was begun by a group of citizens.
The Presbyterian Church took over the college after 25 years.
Named in honor of General Lafayette, a French nobleman, who fought at George Washington's side during the Revolutionary War.

Turn right on 611 - Delaware River is on the right as is the Easton - Phillipsburg toll bridge.

Marker - Easton Forks of the Delaware - laid out by William Parsons - 1752 on left.

Note rock strata on left side of the road - mostly limestone.

This part of Rt. 611 is cut out of the rocks.

Call attention to the fact that we are in Pennsylvania and across the river is New Jersey.

Note how water has eroded the river banks.

Williams Quarry
This is a soapstone or steatite quarry. The quarry was opened about 1883 and continued operations until 1947. It is considered by many geologists to be the most important mineral collecting quarry in Pennsylvania as 44 minerals are reported to have been found there. Serpentine (a light green mineral) was used for paper filler and more recently was used in terrazzo floor tile. The quarry is now owned by the City of Easton. A large rock slide in 1963 occurred in the south part of the quarry. If the quarry had not had the area to absorb the rocks, much of Rt. 611 would have been covered by the debris. Trespassing is prohibited!

There are many towering rocks on left.

Old stone buildings in varying conditions on left.

Look at the number of exposed rocks in the river

Call attention to the fact that the road follows the river, also that we are riding on the Delaware River Flood Plain. (Rounded pebbles can be found along the road.)

Century Inn - Build in 1812.

Cement mill in the distance - Mills were located here because of source of limestone which is an almost perfect composition for cement.

Company houses.

Portland Cement Company Marker - 1871.

Three Limestone kilns at railroad on left.

Tower in the distance.

Quarry.

David Brainard Marker on left, before Alpha Cement plant - Turn left - Monument is on right at the top of the hill.
Brainard was a young missionary who traveled throughout the country preaching the gospel to the Indians and settlers. His cabin was the meeting place and was located in the vicinity of the monument.

Notice rounded mountaintops and rounded hills. This is indicative of the limestone area.

Pennsylvania German buildings - stone on three sides, wood on the fourth.

A good view of the cement quarry on right.

Turn around at old barn and return to Rt. 611 - North on 611.

In Martins Creek, right turn at traffic light.

Look at rocks on both sides of the road when going through the road-cut. These show good bedding planes and cleavage joints.

Stop at Centerfield School on left.

REST STOP

Turn left onto Rt. 611.

Turn left off 611 to see:

Trinity Lutheran (Evangelical) Church - 1864.
Reformed Church - 1837.
Cemetery with a headstone dated 1765.

Continue up road to Mt. Zion Church at top of hill on Rt. 611.

Look toward the Delaware River to see the working of a gravel pit. This is strip mining of glacial drift.

Drive on to Rt. 611 and turn north.

Wind Gap can be seen to the left.

Shales and limestones underlie the soil in this area.

Split rail fences can be seen.

Contour farming is practiced.

Continue north on Rt. 611.

Village of RICHMOND - Richmond Hotel and Church at crossroads.

On left - Apiary - place where bees are housed.

Watch for features of old houses - doors, chimneys, window sills, window panes - three on top, two on bottom.

Christ Evangelical Reformed Church - 1764 on left, - also cementery.

Village pond at Centerville on right with ducks and swans. A wasteland area was converted into a beauty spot and provides water for village fire protection.

Unusual home on the left with eagles, roosters, and horses in bronze.

Excellent view of Delaware Water Gap. Straight ahead.

Glacial rock used for stone fences, walls of homes, and foundations of barns and houses.

Delaware Water Gap - named because of the gap cut through the Kittatinny Mountain by the Delaware River. The Indians called it a "Mountain with a hole in it". Height on New Jersey side is 1600 feet, on Pennsylvania side is 900 feet. There may have been a large lake, possibly 50 miles in length, and as high or half as high as the mountain, obstructing the path of the Delaware River. The great pressure caused the break through the mountain forming the gap.

Approaching Mt. Bethel - notice glacier rocks. Some geologists believe there were three different glaciers that covered the county. Glaciers move forward very slowly - only a few feet per year. Each glacier probably lasted several thousand years. The land is scoured and gouged out as glaciers move across it. When a glacier recedes, it leaves behind rocks and other materials. Around Mt. Bethel, we find the most extensive sand and gravel deposits in the county. Materials vary from sand to boulders 15 feet in diameter.

Limestone part of county is south of here, now entering slate area.

Left turn at Mt. Bethel - toward East Bangor.

Mt. Bethel is on right. Notice in the excavation a large conglomerate rock. (small rocks fused together to form a large rock.)

Kittatinny Mountains on right mark the northern end of the county.

Glacial rocks are in fields on left and right sides of road.

Mt. Bethel - biblical name chosen for first church erected here by David Brainard.

First slate company formed in 1806.

Slate was used for roofing, school slates, blackboards, shingles, table and counter tops, mantlepieces, vaults, chimney pieces, fence posts, and walks.

Slate piles ahead and on the sides of the road. Notice how plants are growing on these piles.

Slate quarries on right - as deep as 700 feet.

Small buildings are where the slate is sliced.

Slate Industry Marker on right.

Dairy feed and poultry feed mill on right.

BANGOR - named for a slate town in Wales. Slate was discovered here by Robert M. Jones, the founder of the borough, about 1850. Town was settled mainly by Welsh slate workers.

PEN ARGYL - Founded in 1868 by Welsh slate workers. Incorrectly said to have been named for William Penn and the Duke of Argyl. Name is derived from the Welsh word Pen meaning mountain and a Latin word Argilla meaning clay or slate. The area had about 60 mills in operation, now there are about seven operating. Pen Argyl and Bangor are known for their garment mills. Approximately 75% of the blouses manufactured in the United States are made in this area. There is plenty of work for women in the garment mills, but not too much work for the men in the area.

Turn right in PEN ARGYL toward WIND GAP.

Notice the boulders in the lawns and along the sides of the road.

Church on the right with walls made of "fieldstone", which in this area refers to glacial deposits.

Gap in Kittatinny called Wind Gap north of traffic light.

Town was named from the gap in the mountains, through which no stream passes.

This is an abandoned water gap as the ridge was cut by a stream which has now disappeared. Received its name because occasionally winds are turned or directed by these gaps to such an extent that they are noted by local residents.

Left turn at stop light. South on Rt. 115.

On right at the end of Wind Gap there is a Sullivan Trail Marker.

Continue on Rt. 115.

Old natural stone houses are on the left.

Split rail fence is on the right.

BELFAST - Name was taken from Belfast, Ireland because some of the settlers were Ulster Scots.

Turn right at Belfast Hotel on right toward Cherry Hill.

****

NO LONGER TO BE SEEN

FILETOWN - So called because people used files in making of gunlocks.

BOULTON - Located on the Bushkill Creek between Belfast and Schoeneck. Was the site of The Henry Rifle Works 1792, and was named for William Boulton, a metal manufacturer in England. First bar of pig iron made in the county was turned out from this forge in 1809. Ore deposits from below Belvidere supplied the furnace. Remains of foundation on right before crossing bridge.

****

Turn left toward **NAZARETH**.

Martinsburg Shale can be seen on the banks and on the sides of the road.

Old school house on the left.

CHERRY HILL - Good view of the valley from top of hill.

Slate fence posts on right.

Schoeneck Moravian Cemetery on left.

Schoeneck Moravian Church founded in 1762 on left.

Nazareth Park on right.

Leaving slate area and entering the limestone part of the county.

NAZARETH - Named for the town of Galilee in Palestine. Tract of 5,000 acres was sold to George Whitefield in 1740 by William Allen for £2,200. Peter Boehler and other Moravians built the House for Whitefield. The tract was sold to the Moravians in 1741 by Whitefield for £2,500.

Grape and Ivy fence and Hitching Posts on N.E. corner at first traffic light in Nazareth. Turn left at traffic light E. Center St. - Whitefield House two blocks on right.

George Whitefield was a famous English evangelist who planned to build an orphanage and school for Negroes on this site. The portion up to the bricks was built in 1740 by the Moravians for Whitefield while he owned the land. The remaining part of the building was completed in 1743-44 after the Moravians bought the land.
The Gray Cottage beside the Whitefield House is the oldest building in the County. It was completed in 1740 by the Moravians who were building the Whitefield House.

Drive to Square.

Look for Civil War cannon on the square and Moravian Church on WSW corner, 1861.

One block west on W. Center Street.

Nazareth Hall - built for Count Zinzendorf in 1754 in hopes that he would become a permanent settler. He did not return to America, so it became a boarding school for Moravian boys. Has served as a Military Academy, a children's home, and is now converted into apartments. Memorial on front lawn is to honor patriotism of SONS OF NAZARETH HALL 1861-65.

West on Rt. 248.

In 1826 cement was discovered in Northampton County. Sacks of cement were produced in 1850. The development of the kiln in 1890 aided in the growth of the industry. In the early 1900's the county led the nation in cement production.

Road protector above road to protect cars from buckets of limestone when it was being taken from one mill to the other. This means of transporting limestone has been discontinued.

Cement truck depot to the right at the Georgetown crossroad.

Rt. 987 to Klecknersville, now back in the "hard" slate area, turn right to Chapman Quarries. Chapman Quarries was named for William Chapman who developed the slate quarries of the area.

Notice how waste slate was used:

- Slate houses
- Slate school (now a factory)
- Old jail
- Slate smokestack on right side of road
- Slate fence posts
- Slate foundations of houses

Quarries on both sides of the road.

Pump outdoors and outhouses.

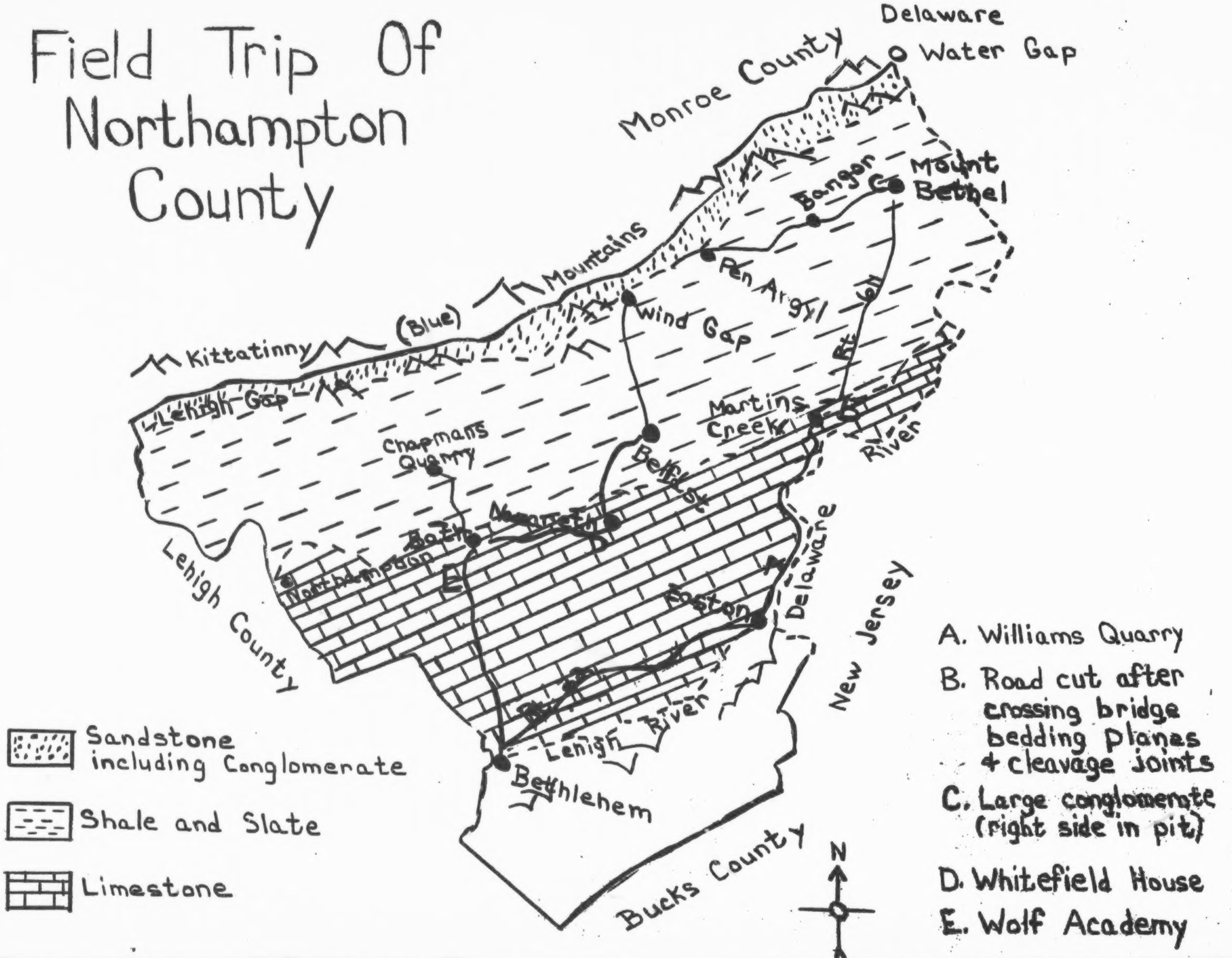
Turn around, return to Bath watching for slate fence posts on both sides of the road on Rt. 987.

Rt. 512 to Bethlehem.

Wolf Academy - a mile below Bath in East Allen Township. A group of English Presbyterians built the stone academy before 1790. George Wolf, the seventh Governor of Pennsylvania, was a student and later the teacher of the Academy. He was the founder of Pennsylvania's Public School system.

The Academy is boarded-up at present, but the Wolf Academy Restoration Society is trying to raise money to restore the Academy.

Field Trip Of Northampton County


Delaware Water Gap
Monroe County
Mount Bethel
Bangor
Pen Argyl
Mountains
Wind Gap
(Blue)
Kittatinny
Lehigh Gap
Martins Creek
River
Chapmans Quarry
Belfast
Nazareth
Bath
Northampton
Lehigh County
Delaware
Easton
New Jersey
Lehigh River
Bethlehem
Bucks County
N
Sandstone including Conglomerate
Shale and Slate
Limestone
A. Williams Quarry
B. Road cut after crossing bridge bedding planes + cleavage joints
C. Large conglomerate (right side in pit)
D. Whitefield House
E. Wolf Academy

GEOLOGY IN YOUR OWN BACKYARD

A stroll up the first few miles of the Monocacy Creek can show you much geology. If we start our walk below the Hill to Hill Bridge in Bethlehem and proceed northward along Conestoga Street to Union Blvd. and then to Illick's Mill, we can in the course of an afternoon learn and see much, pertinent to local geology.

It is not necessary to leave the Bethlehem city limits and this walk can be rewarding in other ways than geological satisfaction, for one portion of it has long been known to bird watchers as an ideal area for counting our feather friends.

Between Union Blvd. and the old stone bridge over the Monocacy below the Hotel Bethlehem, the creek flows through quite a deep valley. It is not deep enough to call it a gorge (slightly under 100 feet), but it is a relatively new course for the creek.

Henry Borhek, in an unpublished thesis on file at Lehigh University, shows that at the beginning of the last ice age the creek did not occupy this channel but flowed roughly in a southwest direction from a point (possibly Illick's Mill) to join the Lehigh River near the site of the old Central Railroad of New Jersey roundhouse below the end of W. Market Street. This original channel was buried with glacial rubble during the last visit of ice to this area and the Monocacy was diverted to carve its present channel to meet the Lehigh further east. The tremendous supply of water from the melting ice made this cutting easy, and the valley now crossed by the Broad Street Bridge thus came into being.

Channel Discoursed

At the time when workmen were digging the cellar for the home for Prof. Williams of Lehigh University, they came upon the old, rubble-filled, preglacial channel of the Monocacy. The site on Prospect Avenue is now the Catholic Convalescent Home. Subsequent cellar digging elsewhere in West Bethlehem made the tracing of the old channel possible.

Another glacial deposit existed at the site of the present armory at Prospect and 2nd Avenues. Long known as Rauch's gravel pit, and still observable although considerably obscured, this deposit of pebbles and gravel was another bit of evidence that the ice was involved with the story of the lower Monocacy Valley. In the low, man-made bluff behind the armory's parking area, one may still find an assortment of debris representing numerous rock types whose origins lie considerably north of Bethlehem.

This post-glacial valley is cut in the Allentown limestone. As one walks up to, under, and beyond the Broad Street Bridge, thick-bedded outcroppings of this rock form cliffs along the Lehigh County side of the creek (below the spur route). Buildings completely obscure similar outcrops on the eastern side of the stream. As you go, you are walking with the dip of the beds, which is north. This is the same limestone through which the builders of the spur route had so much trouble excavating.

This limestone it is said to have been honeycombed with passageways, and one story tells of a cave that connected the basement of the old Sun Inn with an opening on the Monocacy below. This may well have been, but there is no evidence today of such a passageway.

Quarry of Interest

Just beyond the Reichard and Coulston paint mill, on the west side of the creek, is a large abandoned quarry in the same limestone formation. Its walls have much to show us. As one enters the quarry, on the left the beds are arched up into a magnificent anticline worthy of being photographed and used in any text book. Its northern limb is broken by a fault which has been traced to Allentown. This great upfold shows how the rocks of the Lehigh Valley were at one time squeezed together and folded like layers of paper into great corrugations. It shows how some beds were able to withstand pressure and not break, while others failed under stress.

Seen in the beds of this anticline are huge cryptozoa several feet in diameter. They label the rock as Allentown, for they are the index fossils of that formation. Also observable here is an unusual variety of oolite. An oolite is a tiny grain of calcity consisting of layers around a central core. They are found on the bedding planes of the rock and resemble fish eggs, or roe. Usually they are light in color, but in this locality one half of the oolite is dark, the other light. This may seem unimportant to the layman, but to the geologist if presents a problem that calls for an answer.

From this quarry to Illick's Mill it is hoped eventually to establish a nature walk.

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* The committee wishes to thank Dr. Richmond E. Myers, Chairman of Earth Science Dept., Moravian College, for permission to reprint the article - "Geology in your own backyard" - which appeared in the Allentown Morning Call Newspaper.

COMMON ROCKS AND MINERALS OF PENNSYLVANIA

SEDIMENTARY ROCKS

Shale

Shale contains clay minerals, quartz, feldspar, and sometimes pyrite. It breaks or parts along planes called bedding surfaces. Shale is usually brown, gray, or black and is one of the most common of the sedimentary rocks. It is a source of clay and is used in ceramic and brick manufacturing.

Limestone

Limestone is mostly calcite with traces of clay, dolomite, and quartz. Most commonly it varies in color from bluish white to blue-gray and almost black. Limestone is a relatively soft rock. It is quarried for chemical, metallurgical, and agricultural lime when it is relatively free from silica, iron, and aluminum impurities.

Coal

Coal is plant material which has been partly decomposed by bacterial and chemical action and then compressed. The effects of compression and heat determine whether the coal is bituminous or anthracite, the anthracite being the result of the higher pressures and temperatures. If the pressure and temperature increases beyond this, graphite begins to form. Coal is one of our important fuels.

Conglomerate

Conglomerate is made up of large to small, rounded pebbles, usually held together (cemented) by silica or calcite. A common name for this is "puddingstone". It formed near ancient shorelines.

Sandstone

Sandstone is composed of small quartz grains very often cemented together by silica or calcite. If the sandstone is nearly pure quartz, it can be used in the manufacture of glass. When it is pure it is white, but more often it is stained yellow, brown, or red because of the presence of iron oxides. It is a hard rock often suitable for use as a building stone.

IGNEOUS ROCKS

Granite

Granite is a light-colored rock composed of quartz, feldspar, mica, and usually a little hornblende, with numerous other minor minerals. It is used as a building stone when sufficiently dense and massive. "Graphic Granite" is a mixture of quartz and feldspar which is often used as an ornamental stone. Granite is a common igneous rock, but is not as abundant in Pennsylvania as it is in many other states.

Diabase

Diabase is a dark-colored basic rock containing amphibole, feldspar, and pyroxene minerals. Diabase occurs as thin tabular bodies of rock called sheets, dikes, or sills, which have cut upward through sedimentary rocks. Many small dikes are present in southeastern Pennsylvania. Large deposits of massive diabase have been quarried for monumental stone and building stone; it may also be crushed and used as road fill or ballast. Diabase is commonly referred to as "traprock" or "ironstone".

Rhyolite and Basalt - collected in Adams, Lebanon, and Franklin Counties.

Rhyolite, andesite and basalt are fine-grained volcanic rocks. Their individual mineral components cannot be distinguished by the naked eye except in rare instances.

Rhyolite is a light-colored, usually violet to purple, extrusive igneous rock composed of potassium-rich feldspar, high temperature forms of quartz, and a glassy matrix. It has approximately the same composition as granite. Individual feldspar may be large enough to see with the naked eye.

Basalt is a black, dense, extrusive rock containing calcium-rich feldspar, pyroxenes, and amphiboles. It is the most common rock type of large lava flows. Basalt is commonly altered to epidote and clorite. Cavities, called amygdules, are often filled with zeolite minerals. All of these rock types are relatively rare in Pennsylvania. Rhyolite is found in the western half of Adams County and basalt near Jonestown in Lebanon County in small amounts.

METAMORPHIC ROCKS

Marble may be collected near the town of Embreeville in Chester County and the Williams Quarry north of Easton. Marble is composed of calcite and/or dolomite that has been recrystallized during metamorphism from an original limestone or dolomite. It is a massive, coarse grained rock that often contains minor accessory minerals, such as mica and chlorite, which give it a streaked appearance. Individual calcite or dolomite crystal faces can be seen with the naked eye. Marble, like limestone and dolomite, bubbles when treated with cold, dilute hydrocloric acid. It is widely used as a building stone. When it contains green serpentine in large amounts, it is called verde antique, and is then an economically valuable ornamental stone.

Schist

Schist is characterized by a thinly layered or foliated appearance. It has formed from the metamorphism of a shale or a sandy shale. It contains large amounts of mica, which are seen as shiny flakes along the layers. Schist may, however, contain many other minerals, especially quartz, feldspar, and garnet. It is the most common metamorphic rock in this state.

Gneiss

Gneiss is a banded rock usually characterized by alternating light and dark bands. The light bands are generally muscovite, quartz, or feldspar and the dark ones contain biotite or hornblende. Gneiss forms in a manner similar to schist, from shales or sandy shales, but, under conditions of higher temperature and pressure. In addition, the chemical composition of rocks which alter to gneiss may also be different from the composition of rocks which alter to schist.

Slate

Slate is generally a gray-colored rock with smooth, thin cleavage planes. It is composed of fine-grained clays, fledspars, micas, and quartz. Slate is formed from the metamorphism of fine-grained shale or mudstone. Found in southeastern Pennsylvania in Lancaster, York, Lehigh and Northampton Counties, it has been used for roofing slate and in the manufacture of roofing granules.

Serpentine

Serpentine is a black to green-colored rock composed of serpentine-type minerals and talc or clorite, all of which are essentially hydrous magnesium silicates containing lesser amounts of aluminum and iron. It is often spotted with small, black grains of magnetite. Serpentine is usually soft and massive. When green in color, it may be used as a building stone, or in rare cases as a semi-precious gemstone. The gemstone name is williamsite and is one of the notable, although rare, gem-mineral occurences in Pennsylvania. Serpentine occurs in several locations in southeastern Pennsylvania, but is not a common rock type. It has been altered from a basic, igneous rock called peridotite.

Source: COMMON ROCKS AND MINERALS OF PENNSYLVANIA
Educational Series No. 1
Commonwealth of Pennsylvania
Department of Internal Affairs
Second Edition 1962

How Can We Identify Rocks?

This key from Nature and Science Magazine is valuable for identification of the four most common kinds of sedimentary rocks. Answer the question on line A by examining the specimen. Your "yes" or "no" answer will steer you to the next question to answer. Each question and answer will lead you to the name of the sedimentary rock.

A. Can you see individual particles of mineral or rock that make up the specimen without using a magnifying lens? If yes, see line 1. If no, see line B.

   1. Is the specimen composed of rounded particles? If yes, see lines a and b.

      a. If the particles are large pebbles, the rock is conglomerate.

      b. If the particles are sand-sized grains of quartz, which will scratch glass, the rock is sandstone.

B. If you cannot easily see the particles of minerals or rock without using a magnifying lens, see if the particles of rock are arranged in layers. Is the rock too soft to scratch glass? If yes to all questions, see line 1.

   1. Does the rock split easily into layers? If yes, see line a. If no, see line b.

      a. If the luster on the split surface seems silky, the rock is slate, not a sedimentary rock. If the surface is dull the rock is shale.

      b. If it does not split easily into layers, the rock is probably limestone. (Chemical test can be applied.)

Source: Nature and Science Magazine
October 18, 1965 Issue

KEY FOR THE IDENTIFICATION OF COMMON ROCKS AND MINERALS

DIRECTIONS: Since this key makes use of such characteristics as color, hardness, and effervescence in acid, as well as crystalline structure, the following materials will be found extremely useful.

A knife blade, steel awl or sharpened crochet hook, an iron nail, a sheet of glass about 3" x 4", broken window pane or a glass bottle; hand lens or magnifier about 10x in magnifying power; hydrochloric acid, concentrated, or commercial muriatic acid diluted in an equal quantity of water in dropper-bottle, provided with glass or rubber stopper. An old tincture of iodine bottle will prove satisfactory. A small, three-edged file, used in the science laboratory for cutting glass tubing, is an excellent substitute for a knife blade or steel awl in testing rocks for hardness.

In using this key, observe the unknown rock or stone carefully, noting especially whether light colors or dark colors predominate; whether it is soft and crumbles easily, or hard and resistant to scratching. Be on guard lest you are testing a piece of brick, concrete, cinder block, tile, or slag, since the key cannot be expected to be useful in identifying them.

Read the first two or three lines having the same number and make a choice that applies best to the specimen you are trying to identify. This choice will lead to the name of the specimen or else to some other number in the key. Keep following the key, making all suggested tests; be careful not to omit any of them. When you arrive at the name of a rock which seems to apply to your specimen and wish to make certain you have identified it correctly, read its description in a book about rocks or have its identity checked by an expert.

If you find that you may have made a mistake in identification, go back to the first number in the key where you had the greatest difficulty in making a decision and make an alternate, reasonable choice. If you fail to identify your specimen after several attempts, you probably omitted an important step, or else you have some kind of ore or mineral not listed in the key. About 25 minerals are listed; they are marked with an asterisk (*). Common minerals found in rock collections may include asbestos; gypsum; calcite, pyrite (fool's gold), magnetite, hematite, and limonite (iron ores); malachite (copper ore); galena (lead ore); sphalerite (zinc ore); orthoclase and plagioclase feldspars; kaolin, biotite, and muscovite varities of mica. Look for such specimens in museum collections of minerals or consult books about minerals, preferably those with numerous photographs and colored illustrations, prepared particularly for beginners and amateur collectors.

It is assumed that this key will be used to identify rock fragments at least three inches wide, two inches to one and one-half inches thick, and about five inches long, known technically as good hand specimens. The surfaces to be examined should be freshly broken and unweathered. Rounded pebbles or cobbles, as well as rusty-weathered and honeycombed rocks, are nearly impossible for the beginner to identify with this key or any other known key.

In identifying minerals, the color of the streak is also important. This may be determined by rubbing the mineral specimen against some unglazed white pottery. Broken pottery fragments may be used for this purpose. For example, pyrite appears brassy in appearance, but produces a black or very dark brown streak.

Key Begins Here:

1. Porous rocks, very light in weight, frothy in texture - 2

1. Nonporous rocks, relatively heavy, sinking in water - 3

2. Dissolves in water; tastes salty. **DESERT SALT CRUST (HALITE) (*)**

2. Bubbles under hydrochloric acid. Calcareous **TUFA**

2. Does not form bubbles under acid. Volcanic **PUMICE**

3. Rocks composed of small grains, crystals, or pebbles large enough to be seen with the naked eye or under a hand lens - 4

3. Rocks composed of rather large crystals, in fragments or pebbles, some particles exceeding one-half inch in size - 14

3. Rocks dense in texture, with no separate particles visible to the naked eye or under a lens - 21

4. More than one mineral present; more than one color apparent, "salt and pepper" patterns - 5

4. One mineral in excess; one color predominates - 8

5. Minerals in rather distinct layers or bands - 6

5. Minerals not arranged in distinct layers; rather uniform pattern of colors throughout the specimen - 7

6. Banding conspicuous and of varying width; structure solid; gray, white, pink, or red varieties; generally light-colored. **GNEISS**

6. Bands very narrow; rarely wavy; structure flaky; generally dark-colored. **SCHIST**

7. With quartz grains that appear glassy under a lens, and/or with mica, and/or other blackish minerals throughout; generally rather coarsely crystalline; occurring in gray, whitish, pink, or even red varieties. **GRANITE** See also #30 in key, to felsite.

7. Without quartz; much more feldspar (a light-colored mineral) than mica and/or hornblende (a black mineral). Generally coarsely crystalline and light gray in color. **SYENITE**

7. Without quartz; with more hornblende than feldspar. **DIORITE**

8. Mostly light-colored, very hard, glassy crystals visible. **QUARTZ (*)** Hollow spherical rocks lined with such crystals are called **GEODES.**

8. Mostly sand particles visible, or otherwise not as above - 9

9. Mostly sand particles present; will scratch glass - 10

9. Mostly blackish or greenish crystals present - 11

9. Mostly grayish, whitish, or brownish grains present; will not scratch glass-12

10. Crumbles when scratched with a iron nail. **SANDSTONE**

10. Too hard to be crumbled with a nail. **QUARTIZITE**

11. With needle-like crystals, yiedling fibers when scratched or when scraped lightly with a nail. **ASBESTOS**

11. Coarse-grained; crystals easily seen with the naked eye; color very dark, often greenish, with "salt-and-pepper" pattern. **GABRO**

11. Fine-grained; crystals visible under a hand lens; freshly-broken surfaces should be examined. **DIABASE** (gray); **SERPENTINE** (greenish) (*)

12. Dissolves in water; tastes salty. **SEA SALT (HALITE)** (*)

12. Bubbles plainly visible under acid - 13

12. Bubbles hardly visible under acid, except with magnifier. **DOLOMITE** (*)

13. Crystalline structure visible on close inspection. **MARBLE**

13. No crystals visible, except, rarely, calcite in "pockets". **LIMESTONE**

ROCKS COMPOSED OF RATHER LARGE FRAGMENTS OR CRYSTALS

14. Well-rounded pebbles and sand grains cemented together like "plums" in a pudding. **CONGLOMERATE**

14. Angular, irregular fragments cemented together with fine materials. **BRECCIA.** In volcanic regions the similar **LAVA PORPHYRY** may occur.

14. Rocks of coarse crystals or similar fragments with no cement or apparently none; fused or presses together - 15

15. Rock consisting of more than one kind of mineral. **PEGMATITE**

15. One mineral present; foaming under acid; colorless, white, brown, or red; easily scratched with iron nail. **CALCITE** (*)

15. One mineral present; not foaming under acid - 16

16. White to transparent or colorless mineral - 17

16. Gray to very dark, smoky black mineral - 18

16. Yellow brass-colored minerals - 19

16. Red, brown, or black minerals - 21

17. Thin colorless sheets or flakes; readily scratched with iron nail. **MUSCOVITE** (*) **MICA**

17. Massive crystals or granular resembling glass; milky, colorless to smoky, cannot be scratched with iron nail. **QUARTZ** (*)

17. Massive or granular; milky white to red, cannot be scratched with iron nail. **ORTHOCLASE** (*) **FELDSPAR**

18. Thin, smoky black sheets or flakes; readily scratched with iron nail. **BIOTITE (*) MICA**

18. Massive or granular, cannot be scratched with iron nail; sometimes irridescent. **PLAGIOCLASE (*) FELDSPAR**

18. Granular to cubic masses; lead gray with bright metallic luster, easily scratched with iron nail. **GALENA (*)**

19. Massive but brittle; tarnishing blue; readily scratched with an iron nail; streak black; a copper ore. **CHALCOPYRITE (*)**

19. Granular to massive; crystals cubical; cannot be scratched with iron nail; streak black as above; "fool's gold". **PYRITE (*)**

20. Olive-green; coarse or fine granular rock; rather heavy; cannot be scratched with iron nail. **OLIVINITE (*)**

20. Variegated green; granular compact to massive; easily scratched with iron nail or steel file. **SERPENTINE (*)**

20. Green to black; with shiny lustre; rather heavy. **AMPHIBOLE (*)** or **HORNBLENDE AND PYROXENE (*)**

20. Jet-black; easily scratched or crumbled with iron nail. **BITUMINOUS COAL (*)**

ROCKS DENSE IN TEXTURE: NONCRYSTALLINE, OR WITH MICROSCOPIC GRANULES INVISIBLE TO THE NAKED EYE OR UNDER A HAND LENS

21. Easily scratched with a fingernail or quill - 22

21. Not as above; easily scratched with an iron nail - 23

21. Not as above; may scratch glass - 26

22. Rubs off easily on fingers; powders white. **CHALK - Mainly CALCITE (*)**

22. Greasy or slippery to the rubbing action. **TALC (*) SCHIST**

22. Neither powdery nor greasy, but easily scratched with the fingernail or crow quill. **GYPSUM (*)**

23. Splits readily into layers or sheets - 24

23. Does not split readily; fractures irregularly under hammer blow - 25

24. Dark gray, brownish, or purplish-red; sometimes soft enough to be scratched with fingernail; may be broken by the hands into thinner layers. **SHALE**, or **PHYLLITE** (If lustre is silky)

24. Tougher than above; easily scratched with sharpened iron nail, knife blade, or awl, may be split into thin slabs with aid of cold chisel and hammer. **SLATE**

25. Rusty-colored; rarely forming bubbles under acid, **CLAY-IRONSTONE** or gray, appearing in the form of rounded concretion. **CLAYSTONE.**

25. Whitish or cream-colored, rarely yellowish or rust-colored; readily forming bubbles under acid. LIMESTONE, including STALACTITE and STALAGMITE, also TRAVERTINE. Mainly CALCITE (*)

25. Grayish, hardly forming bubbles, or very small bubbles visible under acid and hand lens. DOLOMITE (*)

26. Dark-colored minerals in excess - 27

26. Light-colored minerals in excess - 30

27. Shiny black; hard to scratch with iron nail; easily scratched with a knife blade, steel file, or awl. Hard coal. ANTHRACITE (*)

27. Neither glassy no shiny; dull black, greenish black, or very dark gray. Often called trap rock. BASALT

27. With smooth surface, shiny or waxy, but not glassy - 28

28. Bright-colored; often handed or mottled. CHALCEDONY, JASPER (*) CARNELIAN (if bright red). SILICIFIED WOOD may appear thus.

28. Dull-colored; grayish or tan tints; chips with shell-like edges; fracture technically conchoidal - 29

29. Edge of fracture or chips translucent, waxy. FLINT (*)

29. Edge of fracture or chips not translucent. CHERT (*)

30. Broken surfaces dull; never glassy; pale shades of green red, or gray; that is, light colored, with a mixture of smaller and larger grains. FELSITE

30. Broken surfaces roughened, but glassy. If white; MILKY QUARTZ (*). If pink-tinted: ROSE QUARTZ (*). Note that quartzite does not appear glassy -9 -10

30. Broken surfaces dull, white or gray, or light brown; chips with shell-like edges - 31

31. Edge neither translucent nor transparent; light gray or light brown. CHERT

31. Edge translucent or transparent; with milky white, or clear and colored bands, or irregular markings. AGATE. SILICIFIED WOOD may also have this appearance.

* * * * * * * * * * * *

Selected References:

Loomis, F. B., Field Book of Common Rocks and Minerals, G. P. Putnam's Sons, 1923 and later printings, New York.

Fenton, C. L. and M. A. Fenton, The Rock Book, Doubleday, Doran and Co., 1940, New York.

Pough, F. H., A Field Guide to Rocks and Minerals, Houghton Mifflin Co., 2nd Edition, 1955, New York.

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Source: Earth and Space Science, A guide for Secondary Teachers, Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, 1963, Reprint 1965

THE IDENTIFICATION OF MINERALS

The identification of minerals sometimes puzzles even the experts. Frequently special equipment or chemical tests must be used, so the beginning collector should not feel discouraged if he has trouble. However, many of the common minerals can be identified easily with the aid of a few simple tests. The most important of these are described below.

Hardness of a mineral is one of the best. A mineral is harder than another if it will scratch it. On this basis a hardness scale has been set up from one to ten, one being softest and ten being hardest. This scale is as follows, with some common minerals and materials which may be used to make the hardness test:

1.	Talc	
2.	Gypsum	Fingernail
3.	Calcite	Copper Penny
4.	Fluorite	
5.	Apatite	Steel Knife Blade
		5½-Window Glass
6.	Orthoclase	
		6½-Steel File
7.	Quartz	
8.	Topaz	
9.	Corundum	
10.	Diamond	

Color is another means of identification. Although some minerals occur in only one color, such as black for magnetite, many others occur in several colors, like quartz.

The luster of a mineral tells how the surface of a mineral appears in daylight. There are two major kinds of luster, metallic and non-metallic. A metallic luster is usually brilliant and looks like a metal. Pyrite is an example. Some of the types of non-metallic luster with examples are listed below:

Earthy:	powdery	(limonite)
Vitreous:	glassy	(quartz)
Resinous:	waxy	(sphalerite)
Pearly:	irridescence similar to pearl	(zeolites)
Greasy:	as if coated with oil	(talc)
Silky:	soft and fibrous	(some gypsum, and serpentine)
Adamantine:	hard and brilliant	(diamond)

Streak is the color of the powder of a mineral. This color is often a lighter color than that of large chunks of crystals of the same mineral. The color of the powder can be most easily seen by "streaking" or scratching the mineral across the surface of a plaster tablet or plaster tile. For example chromite, which looks black has a dark brown streak.

Crystal shape is another good means of identification. Each of the mineral descriptions in this book gives the most common crystal form.

Effervescence, or bubbling, when a drop of hydrochloric acid is added is a good test for carbonate minerals, especially calcite.

Source: Common Rocks and Minerals of Pennsylvania
Educational Series No. 1
Commonwealth of Pennsylvania
Department of Internal Affairs

GEOLOGY OFFERS MANY DIFFERENT FIELDS OF SPECIALIZATION

As with other sciences, geology is divided into numerous special fields of investigation of which the following are typical:

Geomorphology is the science of land forms and the processes by which they were produced. Glaciology is the science of past and present glaciers. Historical geology is the study of past events on earth.

Geologic mapping is the assembling and recording of geologic data on maps. Aerial photographs are commonly used to aid in geologic mapping through photogeologic methods.

Petrology deals with the natural history of rocks, their origin, present condition, alteration products, and decay. Petrography is the systematic description and classification of rocks. Sedimentation is the study of sedimentary rocks and the processes by which they were formed. Stratigraphy is concerned with the description, character, thickness, sequence, age, and correlation of rocks.

Paleontology deals with life on earth in the past as recorded by fossils. Micro-paleontology is concerned only with the small forms of fossils. Paleobotany is the study of fossil plants.

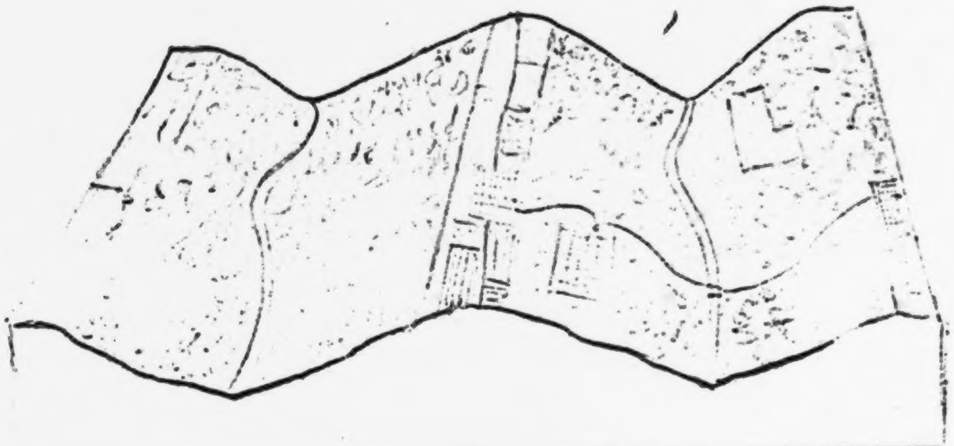
Mineralogy is the science devoted to the classification, composition, and structure of minerals. Geochemistry is the chemistry of earth materials and the chemical factors controlling their origin, migration, and distribution.

Structural geology is the science of the mechanical deformation of the rocks of the earth's crust through folding and breaking. It includes the study of mountain building.

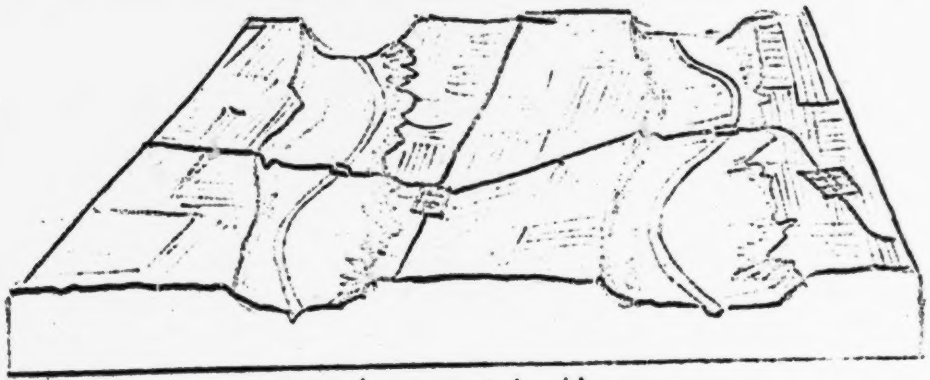
Geophysics is the science of the physics of the earth, and in its broadest interpretation includes the study of the earth, its atmosphere and hydrosphere. It requires an understanding of both physics and geology. It includes such specialized areas of investigation as seismology, the science of earthquakes, terrestrial magnetism, geodesy, meteorology, hydrology, and oceanography. (Of current and increasing importance is the science of earth's satellite - lunar geology. Ed. Note)

Source: Conservation Education (A bulletin) 20036 - No. 19 - Winter 1967
The Conservation Foundation
1250 Connecticut Avenue
Washington, D. C.

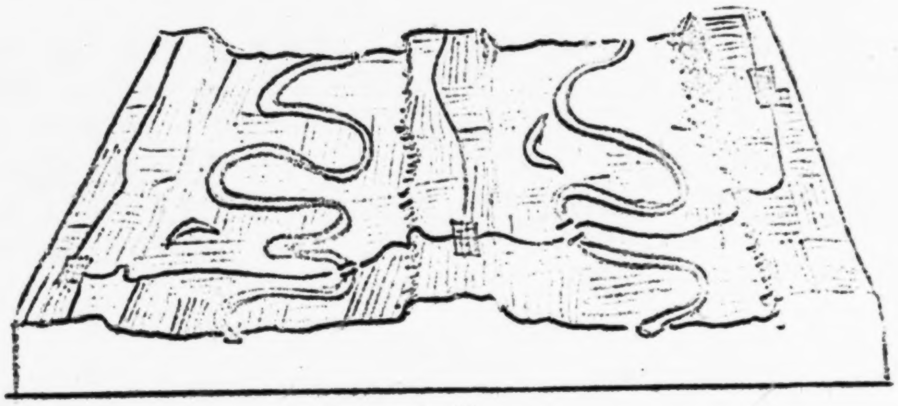
Formation of Valleys



Young Valleys



Mature Valleys

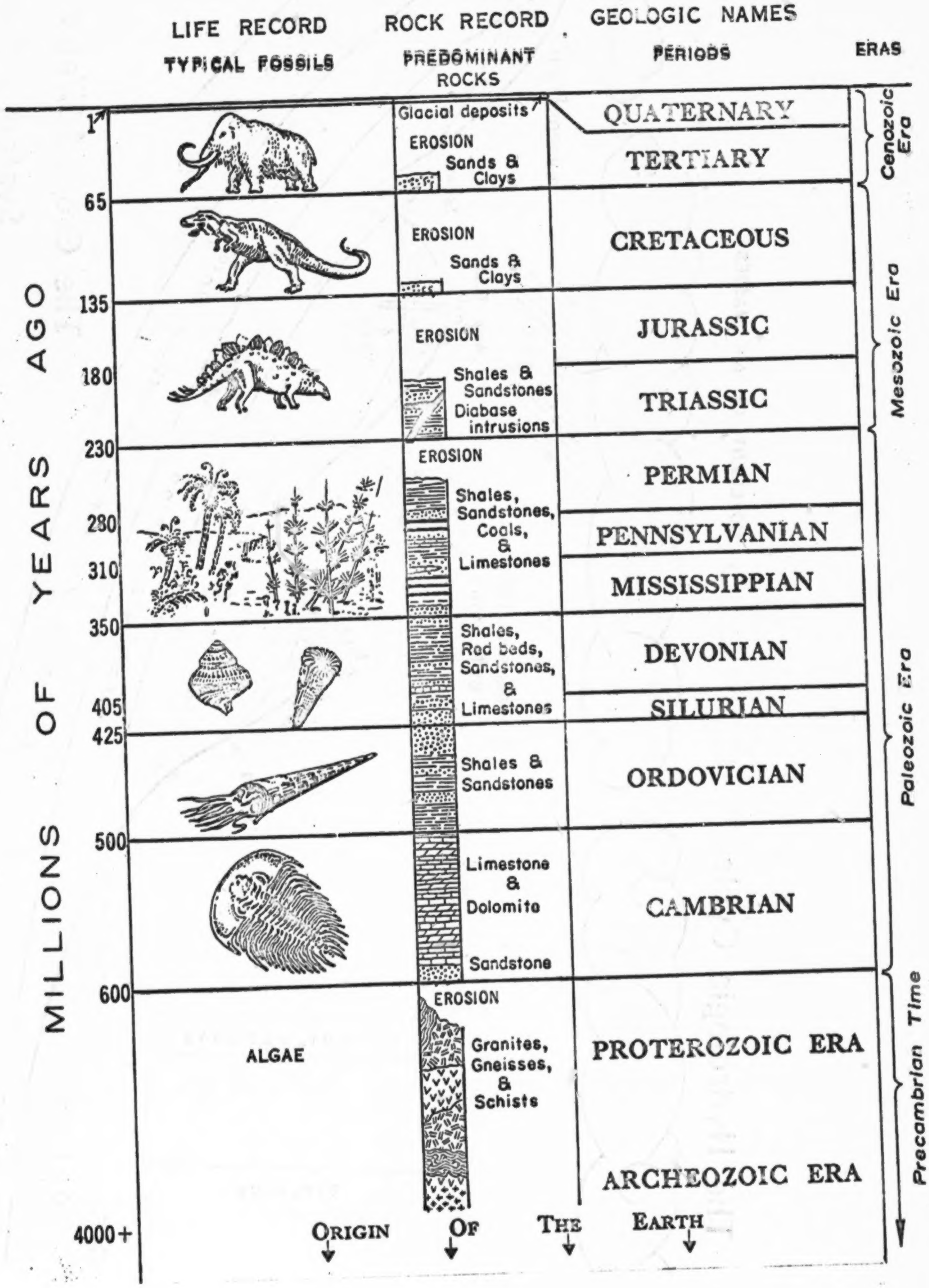


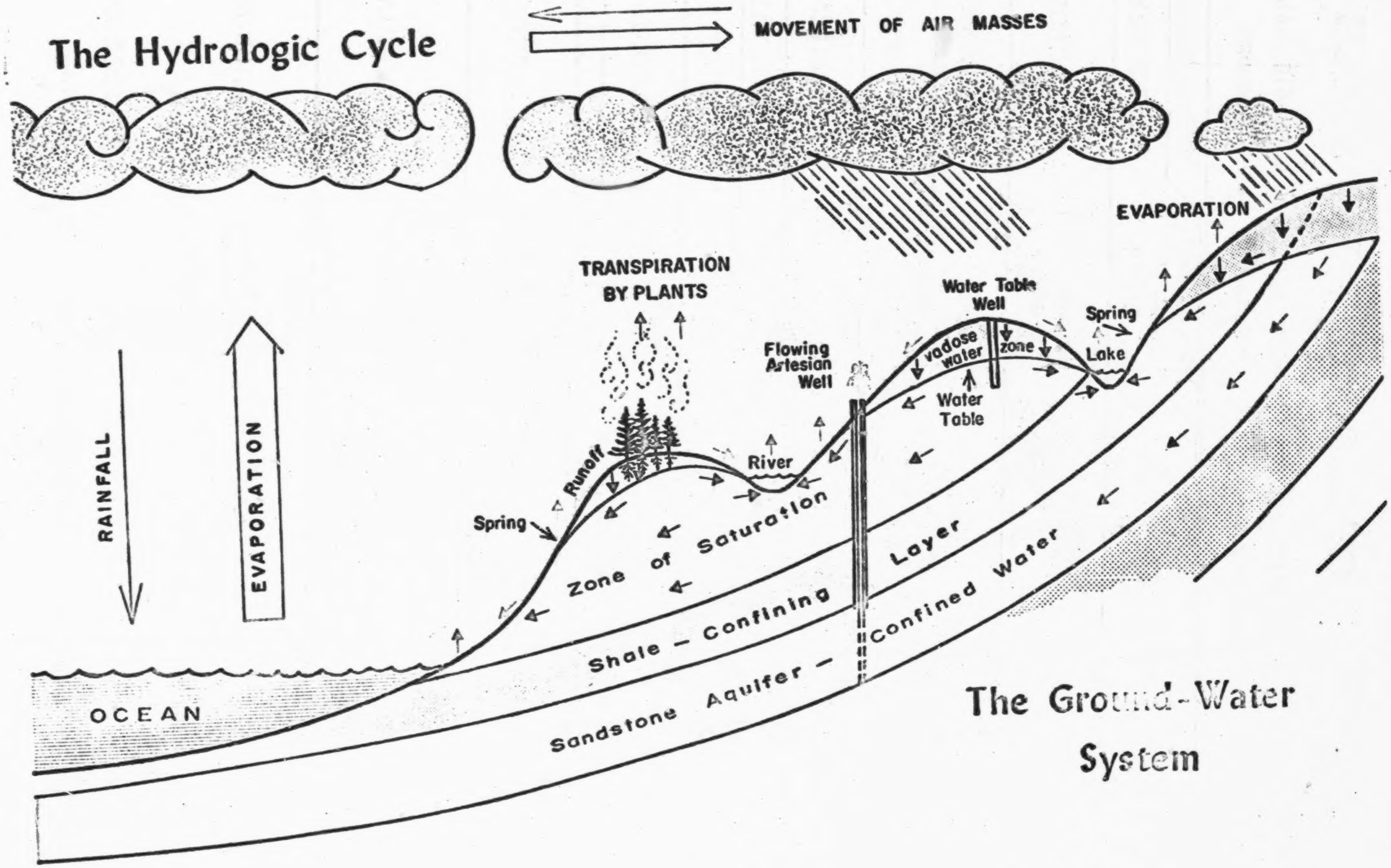
Old Valleys

~ roads ≈ Stream ▦ Settlement

// bridge ▤ Cropland ✿ Woodland

GEOLOGIC TIME SCALE


LIFE RECORD
TYPICAL FOSSILS
ROCK RECORD
PREDOMINANT ROCKS
GEOLOGIC NAMES
PERIODS
ERAS
MILLIONS OF YEARS AGO
1
65
135
180
230
280
310
350
405
425
500
600
4000+
ALGAE
Glacial deposits
EROSION
Sands & Clays
EROSION
Sands & Clays
EROSION
Shales & Sandstones
Diabase intrusions
EROSION
Shales, Sandstones, Coals, & Limestones
Shales, Red beds, Sandstones, & Limestones
Shales & Sandstones
Limestone & Dolomite
Sandstone
EROSION
Granites, Gneisses, & Schists
QUATERNARY
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PROTEROZOIC ERA
ARCHEOZOIC ERA
Cenozoic Era
Mesozoic Era
Paleozoic Era
Precambrian Time
ORIGIN OF THE EARTH

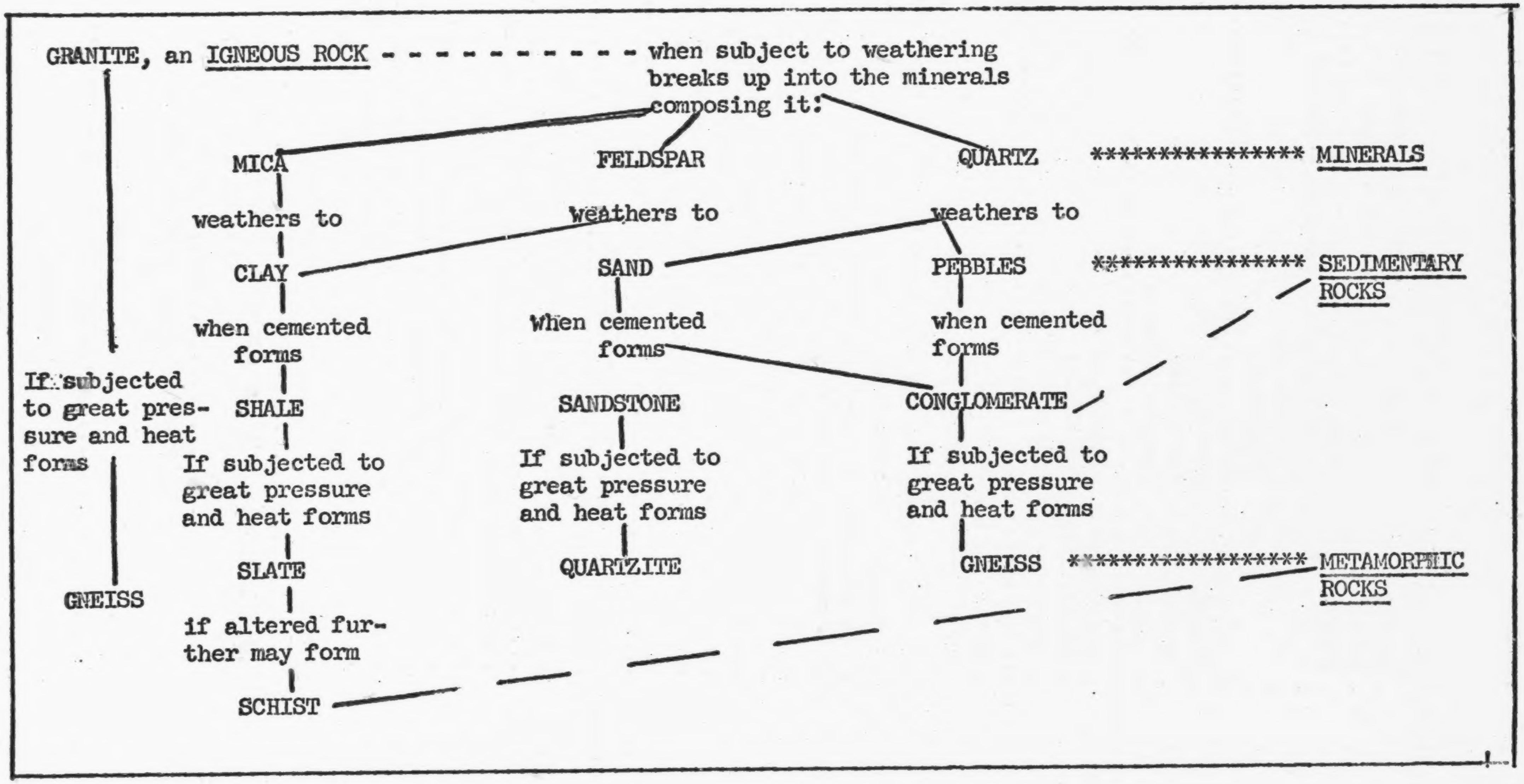

The Hydrologic Cycle

The Ground-Water System

MOVEMENT OF AIR MASSES
RAINFALL
EVAPORATION
TRANSPIRATION BY PLANTS
EVAPORATION
Water Table Well
Flowing Artesian Well
Spring
Lake
vadose water
zone
Water Table
River
Runoff
Spring
Zone of Saturation
Shale – Confining Layer
Sandstone Aquifer – Confined Water
OCEAN

HOW ROCKS ARE CHANGED
FROM
ROCK STORIES AND HOW TO READ THEM, published by the National Audubon Society

Supplemented by rock and mineral specimens, this would make a good exhibit for your room


GRANITE, an IGNEOUS ROCK - - - - - - - - - - when subject to weathering breaks up into the minerals composing it:
MICA
FELDSPAR
QUARTZ
**************** MINERALS
weathers to
weathers to
weathers to
CLAY
SAND
PEBBLES
**************** SEDIMENTARY ROCKS
when cemented forms
when cemented forms
when cemented forms
SHALE
SANDSTONE
CONGLOMERATE
If subjected to great pressure and heat forms
If subjected to great pressure and heat forms
If subjected to great pressure and heat forms
If subjected to great pressure and heat forms
GNEISS
SLATE
QUARTZITE
GNEISS
***************** METAMORPHIC ROCKS
if altered further may form
SCHIST

Generalized Geologic Column for Eastern Pennsylvania and New Jersey
(Divisions marked x are developed in Lehigh Valley and nearby)

Eras	Periods	Formations	Character	Usual Geomorphic Expression
Cenezoic	Quaternary 1 million years	x Recent Deposits	Alluvial deposits along streams	Flood Plains
		x Pleistecone or Ice Age Deposits	Glacial Deposits	Occasional irregular mounds
	Tertiary 40 million years	Subdivided in New Jersey Absent in Pa.		
Mesozoic	Cretaceous 75 million years	Subdivided in New Jersey Scarce in Pa.		
	Jurassic 40 million years	Probably absent		
	Triassic 40 million years	Stockton		
		Lockatong		
		x Brunswick	Red shales and sandstones intruded by dikes and sills of igneous rocks, mainly diabase	Igneous rocks form hills.
Unconformity. Mountain building. Appalachian Revolution.				
Paleozoic	Permian	Absent in eastern Pennsylvania		
Carboniferous 115 million yrs	Pennsylvanian	Coal measures	Coal beds, shales and Sandstones	Valleys
		Pottsville	Gray sandstone and conglomerate of white quartz pebbles; some coal seams in upper part.	Major ridges.
	Mississippian	Mauch Chunk	Red shales; some thin sandstone layers.	Valleys
		Pocono	Gray sandstone	Major ridges

Devonian 50 million years	Catskill	Red and gray sandstone and shale	Valleys and minor ridges
	Chemung	Reddish and gray shale	Valleys
	Portage	Greenish shale	Valleys
	Hamilton	Gray flaggy sandstone and sandy shale	Minor ridges
	Marcellus	Black shale and some fine gray sandstone	Valleys
	Onendaga	Gray cherty limestone	Valleys
	Esepus	Gray sand shale or grit; also known as "caudagalli grit."	Valleys
	Oriskany	Light-brown to whitish sandstone, pea conglomerate, and some limy beds.	Minor ridges
	Helderberg	Gray limestone, shale, and limy shale	Valleys
Silurian 40 million years	Poxono Island	Gray-green sandy shale and some limestone	Valleys
	High Falls	Interbedded red and green shales and sandstones with white sandstones in upper part.	Valleys
	Clinton	Brown and reddish sandstone and shale	Major ridges
	Shawangunk x(Tuscarora)	Massive gray sandstone and conglomerate. of white quarts pebbles	Major ridges

Unconformity. Period of rock folding and later erosion.
Taconic Distrubance.

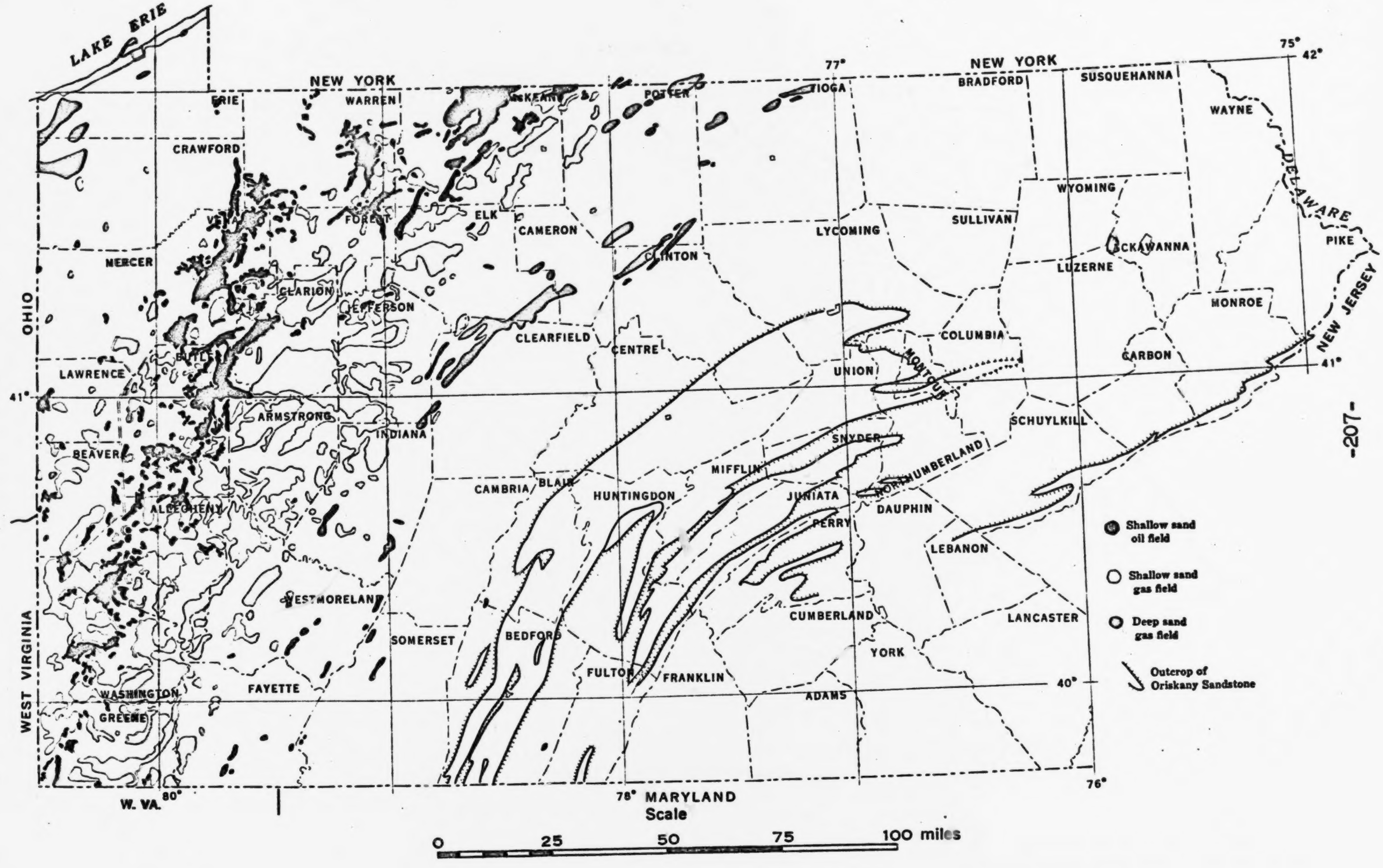
Ordevician 110 million. years	x Martinsburg. 11,000 feet.		Valleys and uplands
	x Jacksonburg. circa 600 feet.	Argillaceous limestone used for cement	Valleys
	x Beekmantown circa 1000 ft..	Interbedded high and low magnesian limestones	Valleys

		x Beekmantown circa 1000 ft.	Interbedded high and low magnesian limestones	Valleys
	Cambrian 90 million years	x Allentown circa 1800 ft. (Conococheague)	Delomitic limestone	Valleys
		x Tomstown * circa 1000 ft.	Impure dolomitic limestones	Valleys
		x Hardyston-circa 400 feet - (Chickies).		
Unconformity	Mountain building and later erosion.			
Proterozoic	Pre-Cambrian.	x Byram Losee.	Light colored gneisses, metamorphosed granites	Hills and ridges
		x Moravian Heights	Gneisses and schists, metamorphosed sediments	Hills and ridges
Archeozoic		x Pochuck	Dark colored gneisses	Valleys, hills, and ridges
		x Franklin	Coarsely crystalline limestone	Valleys, hills, and ridges

*Now called the Leithsville.

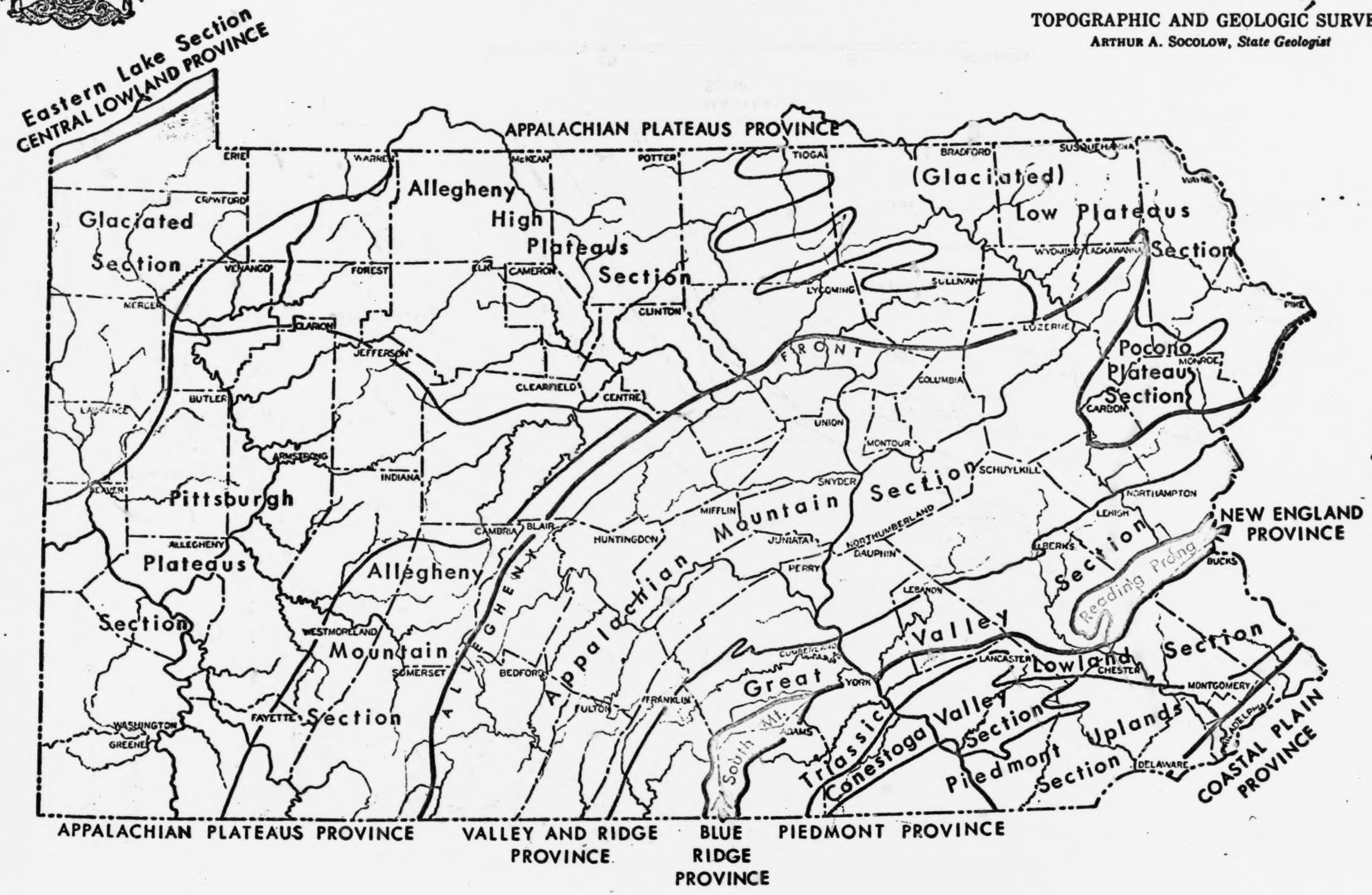
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, *Secretary*
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, *State Geologist*

OIL AND GAS FIELDS MAP OF PENNSYLVANIA


LAKE ERIE
NEW YORK
OHIO
WEST VIRGINIA
W. VA.
MARYLAND
DELAWARE
NEW JERSEY
77°
75°
42°
41°
80°
78°
76°
40°
ERIE
CRAWFORD
WARREN
MCKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
MERCER
FOREST
ELK
CAMERON
CLINTON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
PIKE
LUZERNE
MONROE
CLARION
JEFFERSON
CLEARFIELD
CENTRE
COLUMBIA
CARBON
LAWRENCE
BUTLER
VENANGO
UNION
MONTOUR
ARMSTRONG
INDIANA
SCHUYLKILL
SNYDER
NORTHUMBERLAND
BEAVER
MIFFLIN
CAMBRIA
BLAIR
HUNTINGDON
JUNIATA
DAUPHIN
ALLEGHENY
PERRY
LEBANON
WESTMORELAND
CUMBERLAND
LANCASTER
SOMERSET
BEDFORD
YORK
FULTON
FRANKLIN
FAYETTE
WASHINGTON
ADAMS
GREENE
Shallow sand oil field
Shallow sand gas field
Deep sand gas field
Outcrop of Oriskany Sandstone
Scale
0
25
50
75
100 miles

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, *Secretary*
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, *State Geologist*

PHYSIOGRAPHIC PROVINCES of PENNSYLVANIA


Eastern Lake Section
CENTRAL LOWLAND PROVINCE
APPALACHIAN PLATEAUS PROVINCE
Glaciated Section
Allegheny High Plateaus Section
(Glaciated) Low Plateaus Section
Pocono Plateau Section
Pittsburgh Plateaus Section
Allegheny Mountain Section
ALLEGHENY FRONT
Appalachian Mountain Section
Great Valley Section
Reading Prong Section
NEW ENGLAND PROVINCE
South Mt.
Triassic Lowland Section
Conestoga Valley Section
Piedmont Uplands Section
COASTAL PLAIN PROVINCE
APPALACHIAN PLATEAUS PROVINCE
VALLEY AND RIDGE PROVINCE
BLUE RIDGE PROVINCE
PIEDMONT PROVINCE
ERIE
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
VENANGO
FOREST
ELK
CAMERON
CLINTON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
PIKE
MERCER
CLARION
JEFFERSON
CLEARFIELD
CENTRE
LUZERNE
MONROE
COLUMBIA
CARBON
LAWRENCE
BUTLER
UNION
MONTOUR
ARMSTRONG
INDIANA
SNYDER
SCHUYLKILL
BEAVER
NORTHAMPTON
MIFFLIN
CAMBRIA
BLAIR
HUNTINGDON
JUNIATA
NORTHUMBERLAND
DAUPHIN
LEHIGH
ALLEGHENY
BERKS
BUCKS
PERRY
LEBANON
WESTMORELAND
CUMBERLAND
LANCASTER
CHESTER
SOMERSET
BEDFORD
YORK
MONTGOMERY
FULTON
FRANKLIN
WASHINGTON
GREENE
FAYETTE
ADAMS
PHILADELPHIA
DELAWARE

COMMONWEALTH OF PENNSYLVANIA
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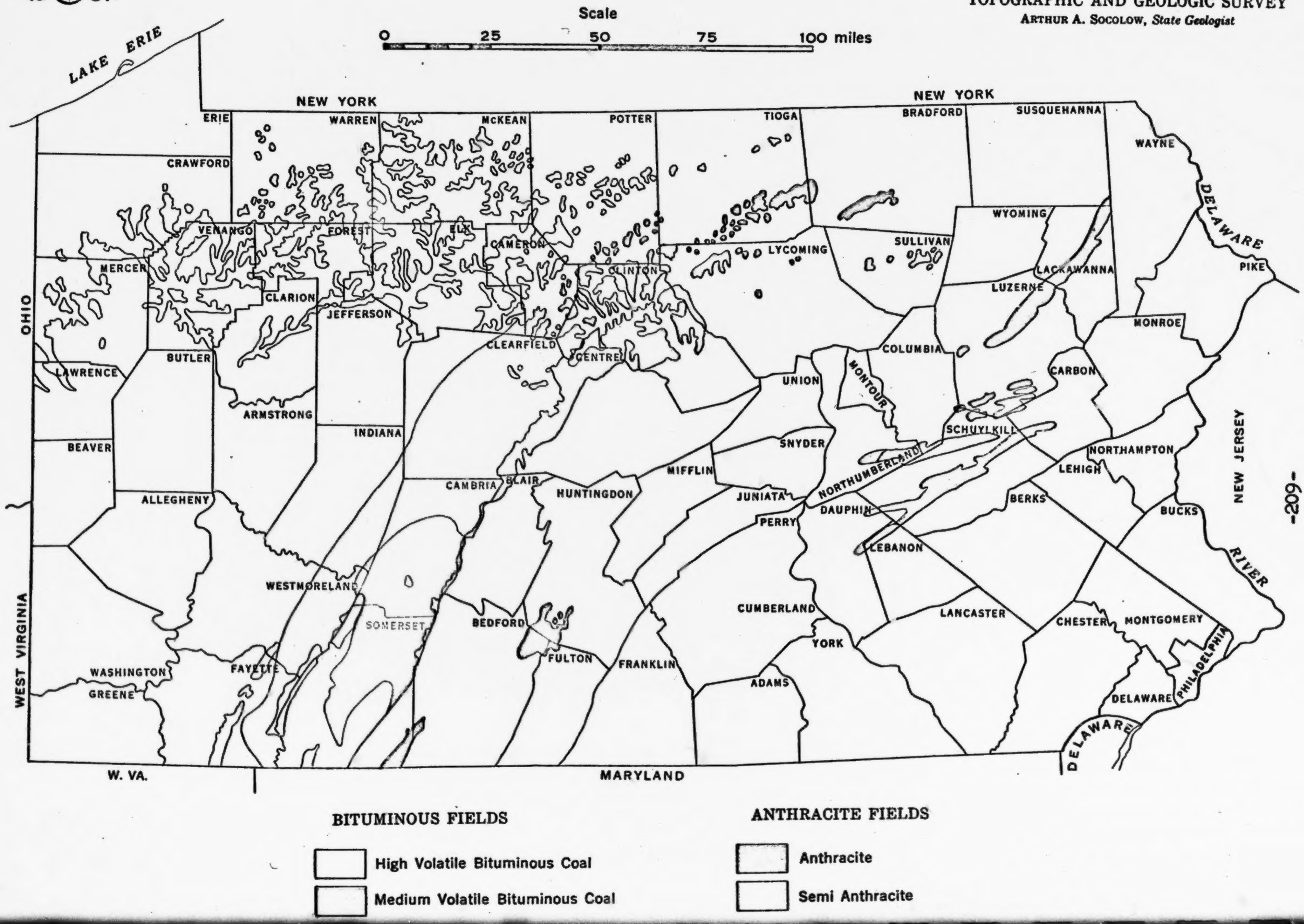
DISTRIBUTION OF PENNSYLVANIA COALS


Scale
0
25
50
75
100 miles
LAKE ERIE
NEW YORK
NEW YORK
OHIO
WEST VIRGINIA
W. VA.
MARYLAND
NEW JERSEY
DELAWARE
DELAWARE
RIVER
ERIE
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
VENANGO
FOREST
ELK
CAMERON
CLINTON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
PIKE
MERCER
CLARION
JEFFERSON
LUZERNE
MONROE
LAWRENCE
BUTLER
CLEARFIELD
CENTRE
COLUMBIA
UNION
MONTOUR
CARBON
ARMSTRONG
INDIANA
SNYDER
SCHUYLKILL
BEAVER
NORTHUMBERLAND
NORTHAMPTON
LEHIGH
MIFFLIN
CAMBRIA
BLAIR
HUNTINGDON
JUNIATA
DAUPHIN
BERKS
ALLEGHENY
PERRY
BUCKS
LEBANON
WESTMORELAND
CUMBERLAND
LANCASTER
CHESTER
MONTGOMERY
SOMERSET
BEDFORD
YORK
FULTON
FRANKLIN
WASHINGTON
FAYETTE
GREENE
ADAMS
DELAWARE
PHILADELPHIA
BITUMINOUS FIELDS
High Volatile Bituminous Coal
Medium Volatile Bituminous Coal
ANTHRACITE FIELDS
Anthracite
Semi Anthracite

GEOLOGIC MAP OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
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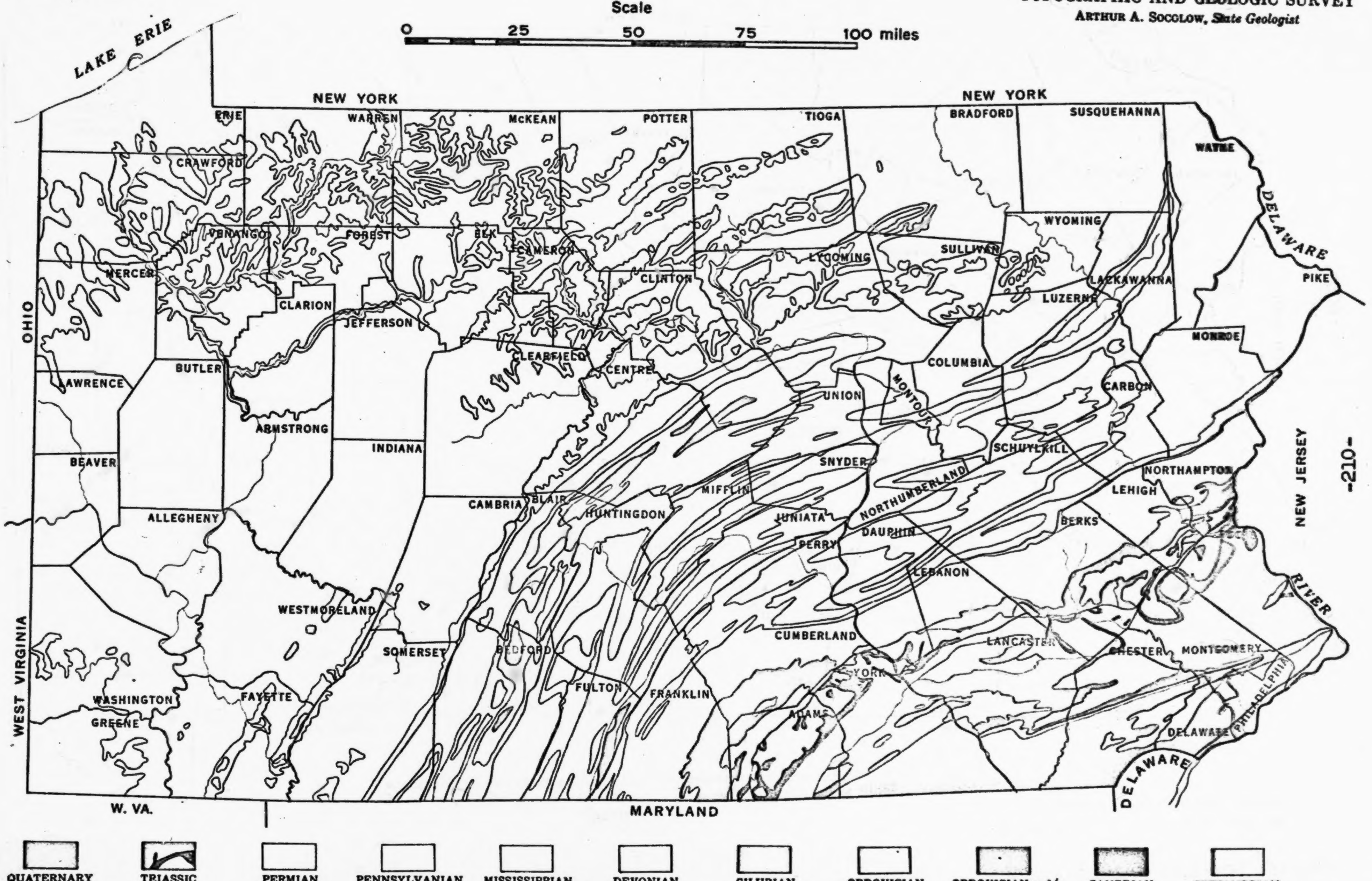

Scale
0
25
50
75
100 miles
LAKE ERIE
NEW YORK
NEW YORK
OHIO
WEST VIRGINIA
W. VA.
MARYLAND
NEW JERSEY
DELAWARE
DELAWARE RIVER
ERIE
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
VENANGO
FOREST
ELK
CAMERON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
PIKE
MERCER
CLARION
JEFFERSON
CLINTON
LUZERNE
MONROE
LAWRENCE
BUTLER
CLEARFIELD
CENTRE
UNION
MONTOUR
COLUMBIA
CARBON
ARMSTRONG
INDIANA
SNYDER
SCHUYLKILL
NORTHAMPTON
BEAVER
LEHIGH
NORTHUMBERLAND
MIFFLIN
CAMBRIA
BLAIR
HUNTINGDON
JUNIATA
BERKS
ALLEGHENY
DAUPHIN
PERRY
LEBANON
WESTMORELAND
CUMBERLAND
SOMERSET
BEDFORD
LANCASTER
CHESTER
MONTGOMERY
YORK
FULTON
FRANKLIN
WASHINGTON
FAYETTE
ADAMS
GREENE
DELAWARE
PHILADELPHIA

QUATERNARY
(0-1 million yrs.)
Sand and gravel.
sand and gravel.

TRIASSIC
(180-230 mil. yrs.)
Shales and sandstones intruded by diabase. (red)
iron, building stone.

PERMIAN
(230-280 mil. yrs.)
Cyclic sequences of sandstone, red beds, shale, limestone, and coal.

PENNSYLVANIAN
(280-310 mil. yrs.)
Cyclic sequences of sandstone, limestone, shale, clay, and coal.
coal, clay, lime.

MISSISSIPPIAN
(310-350 mil. yrs.)
Red beds, shale, and sandstone.

DEVONIAN
(350-400 mil. yrs.)
Red beds, shale, sandstone, limestone and chert.
silica sand.

SILURIAN
(400-425 mil. yrs.)
Sandstone, red beds, shale, and limestone.
gannister, lime.

ORDOVICIAN
(425-500 mil. yrs.)
Shale, limestone, dolomite, sandstone.
slate, limestone, zinc.

ORDOVICIAN and/ or CAMBRIAN
(425-600 mil. yrs.)
Metamorphic rocks-schist, serpentine, gneiss and quartzite.
Building stone.

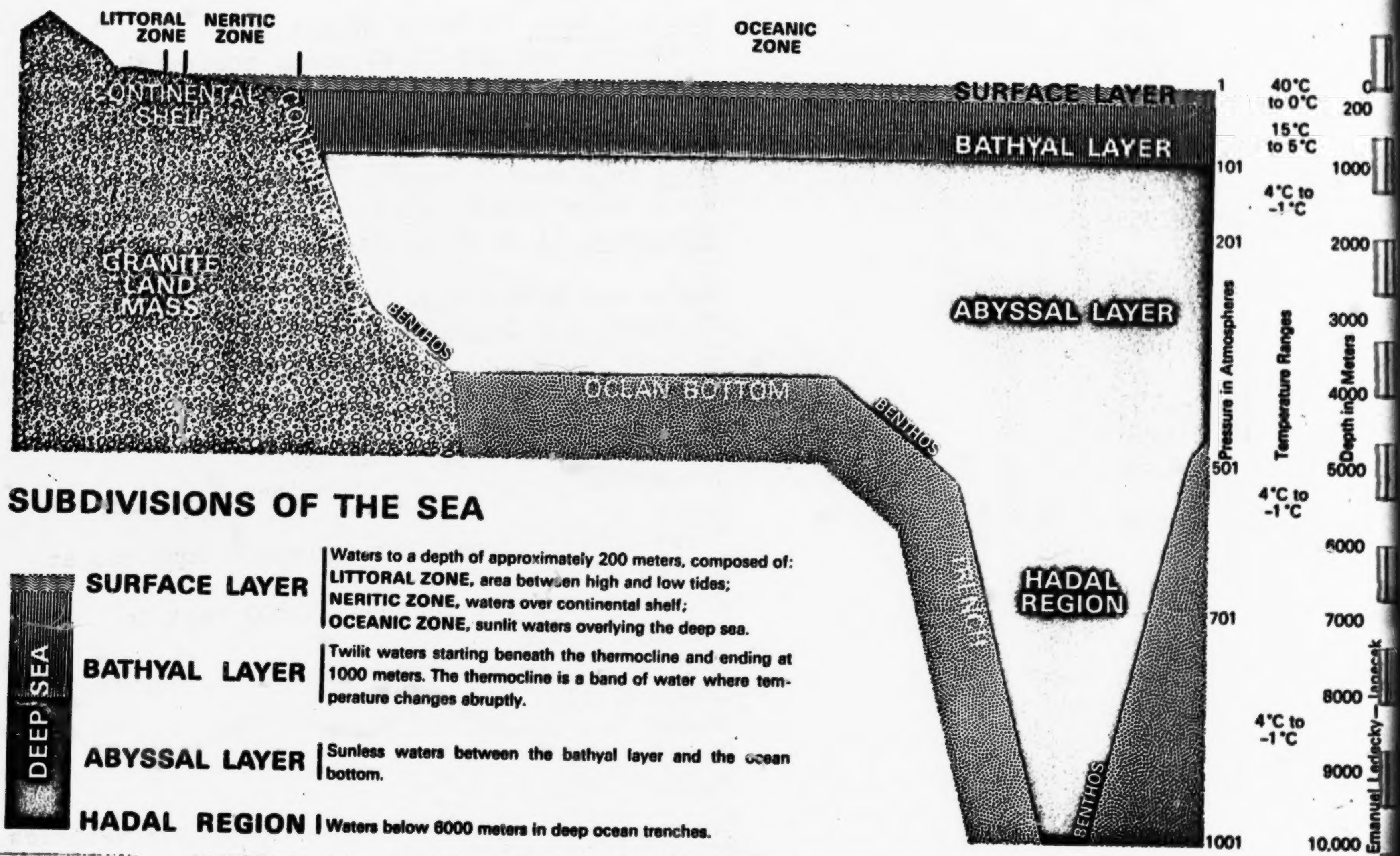
CAMBRIAN
(500-600 mil. yrs.)
Limestone and dolomite; some sandstone and shale.
lime and gannister.

PRECAMBRIAN
(Older than [illegible] mil. yrs.)
Gneiss, greenstone, serpentine and anorthosite.
zinc, building stone, graphite,

A TIME LINE OF MODERN OCEANOGRAPHY

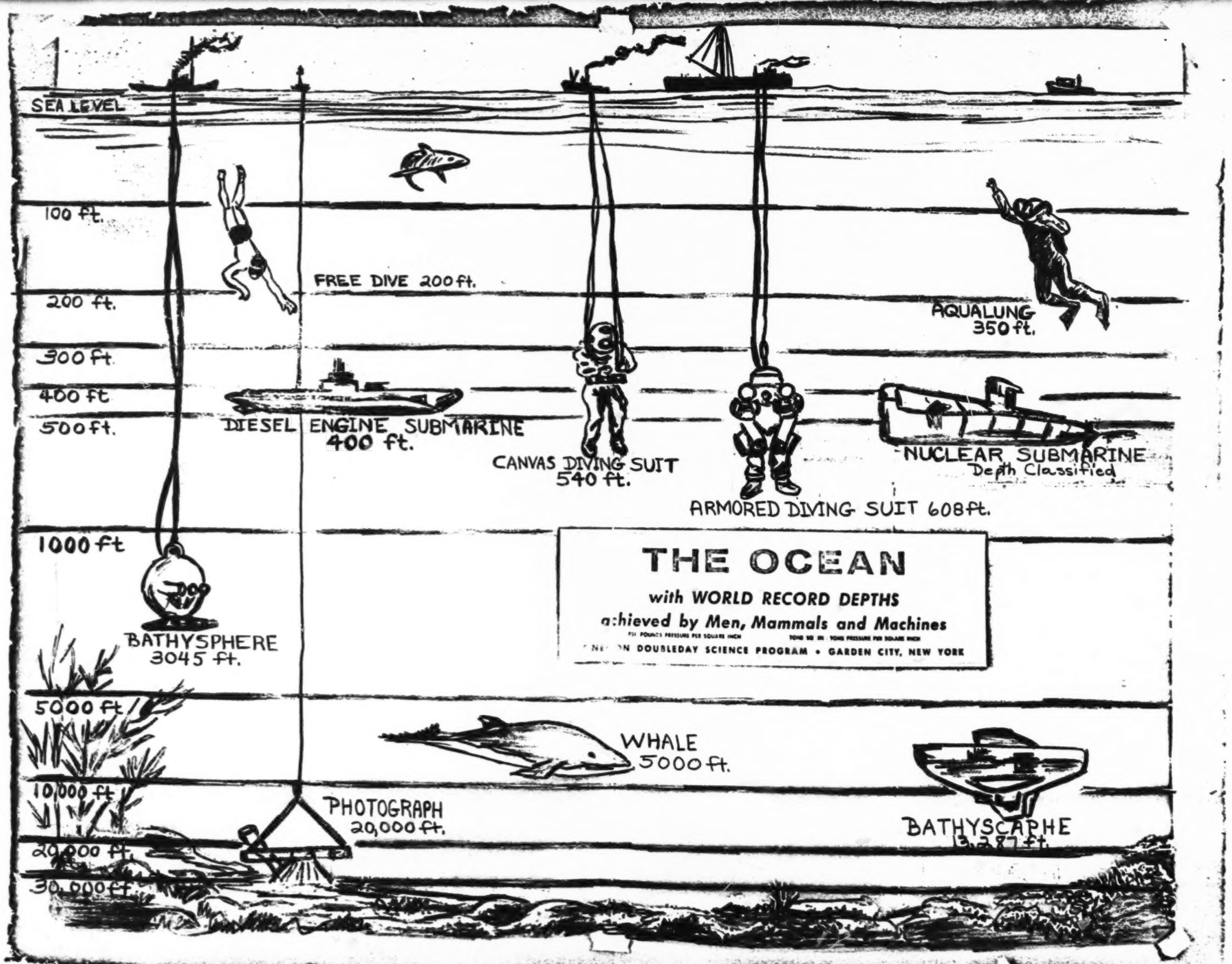
1843	Forbes' Azoic Theory
1849	Brooke's sounding device
1855	Maury publishes The Physical Geography of the Sea
1868-1870	H.M.S. Lightning and Porcupine
1872	Anton Dohrn founds Stazione Zoologica at Naples
1872-1876	H.M.S. Challenger
1877-1880	U.S.S. Blake
1885-1922	Oceanographic studies by Prince Albert of Monaco
1889	S.S. National plankton studies under direction of Victor Hensen
1893-1896	Nansen's Fram
1899	International Council for the Exploration of the Sea founded
1900	Nansen bottle
1910	Michael Sars in North Atlantic
1912	Fessenden designs first sonar equipment
1926-1929	Discovery
1926-1939	William Scoresby
1927	Sir Hubert Wilkins' Nautilus
1928-1930	Dana on global survey
1930	Woods Hole Oceanographic Institution founded
1930-1951	Discovery II in Antarctic
1934	Beebe and Barton make deepest dive in bathysphere
1943	Cousteau and Gagnan design aqualung
1950	Scripps Institution of Oceanography diving team formed
1950-1952	Galathea deep-sea study
1957-1958	International Geophysical Year
1958	Transpolar voyages of submarines Nautilus and Skate
1959	First International Oceanographic Congress at United Nations, N.Y.
1960	Piccard's Trieste reaches 35,800 feet in Mariana Trench
1962	Captain Cousteau's Conshelf I
1963	Conshelf II
1964	Sealab I
1965	Sealab II
1965	Conshelf III
1965	Alvin, one of the first mobile undersea vehicles
1966	Second International Oceanographic Congress at Moscow
1967	Oceanographer Expedition
1968	Sealab III

Acknowledgment is made to Dr. John Lyman for checking the Time Line for accuracy. Dr. Lyman is a former staff member of the U. S. Naval Hydrographic Office and a consultant to the Environmental Science Services Administration and the Office of Naval Research.


LITTORAL ZONE
NERITIC ZONE
OCEANIC ZONE
CONTINENTAL SHELF
CONTINENTAL SLOPE
GRANITE LAND MASS
BENTHOS
SURFACE LAYER
BATHYAL LAYER
ABYSSAL LAYER
OCEAN BOTTOM
BENTHOS
TRENCH
HADAL REGION
BENTHOS
1
101
201
501
701
1001
Pressure in Atmospheres
40°C to 0°C
15°C to 5°C
4°C to -1°C
4°C to -1°C
4°C to -1°C
Temperature Ranges
0
200
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
Depth in Meters
Emanuel Ledecky—Janecek
DEEP SEA

SUBDIVISIONS OF THE SEA

SURFACE LAYER	Waters to a depth of approximately 200 meters, composed of: **LITTORAL ZONE**, area between high and low tides; **NERITIC ZONE**, waters over continental shelf; **OCEANIC ZONE**, sunlit waters overlying the deep sea.
BATHYAL LAYER	Twilit waters starting beneath the thermocline and ending at 1000 meters. The thermocline is a band of water where temperature changes abruptly.
ABYSSAL LAYER	Sunless waters between the bathyal layer and the ocean bottom.
HADAL REGION	Waters below 6000 meters in deep ocean trenches.


THE OCEAN
with WORLD RECORD DEPTHS
achieved by Men, Mammals and Machines
PSI POUNDS PRESSURE PER SQUARE INCH
TONS SQ IN TONS PRESSURE PER SQUARE INCH
NELSON DOUBLEDAY SCIENCE PROGRAM • GARDEN CITY, NEW YORK
SEA LEVEL
100 ft.
200 ft.
300 ft
400 ft
500 ft.
1000 ft
5000 ft
10,000 ft
20,000 ft
30,000 ft
FREE DIVE 200 ft.
AQUALUNG
350 ft.
DIESEL ENGINE SUBMARINE
400 ft.
CANVAS DIVING SUIT
540 ft.
NUCLEAR SUBMARINE
Depth Classified
ARMORED DIVING SUIT 608 ft.
BATHYSPHERE
3045 ft.
WHALE
5000 ft.
PHOTOGRAPH
20,000 ft.
BATHYSCAPHE
13,287 ft.